Suffolk Marine Pioneer: Lessons & recommendations for applying the natural capital approach in England

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Contents

Glossary

Asset register (Evidence)	An inventory of the natural assets in an area, and their condition.
Beneficiaries	One or more persons or groups of persons deriving a direct or indirect advantage.
Better decision making	The outputs of decisions made are less harmful for the natural environment.
Comprehensive (Evidence)	Inclusive of most elements or aspects of information.
Ecosystem services	Functions and products from nature that can be turned into benefits with varying degrees of human input.
Evidence Base	An objective set of information collected with the intention to inform how natural capital planning and interventions can deliver uplifts in ecosystem services.
Governance	The interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens and other stakeholders have their say.
Intervention	A solution or action affecting ecosystem service provision by means of physical, social, political or other appropriate action(s).
Natural capital	The 'stock' of resources upon which society depends, and our approach is intended to secure those assets so they can provide a sustainable 'flow' of benefits.
Natural capital approach	Applying the concept of natural capital with the intent to inform decision making.
Natural Capital Managers	Persons or groups with the ability to direct and influence the processes and people developing and delivering a natural capital plan.
Natural Capital Plan	A strategy that is built up from an evidence led understanding of the functioning of the natural environment within a certain geography. Will set actions, objectives or interventions that deliver environmental improvement and support sustainable use by people.
NCC framework	A practical guide to use natural capital approaches in making decisions published by the Natural Capital Committee. It is intended to support decision makers, including planners, communities and landowners.
Pioneer (the)	The Suffolk based project examining how the natural capital approach might work for the marine & coastal environments when delivered in a local context.
Substitutions	Alternatives from the natural, human or built environment that are able to deliver equivalent benefits to a natural asset.
Value	A change in human wellbeing generated by capital. Not necessarily reflected in market price.

Executive Summary

A natural capital approach - that is applying the concept of natural capital to decision making - was proposed by the Natural Capital Committee (NCC) as a mechanism to meet the aspiration of the 25 Year Environment Plan (25YEP) by recognising the value of the natural environment in day-to-day decision making.

The pathway to deliver the natural capital approach has yet to be verified. Therefore, risk and uncertainty are prevalent for early adopters and the environments they aim to enhance. The Pioneer programme was established by Defra to identify how a natural capital approach could inform place-based decision making for various environments.

This document recounts the experience, lessons and recommendations of the Suffolk Marine Pioneer in applying natural capital to estuarine salt marsh through four reporting themes: Change, Governance, Method, and Funding.

Natural Capital can be defined as: The elements of nature that directly or indirectly produce value to people, including ecosystems, species, freshwater, land, minerals, the air and oceans (NCC, 2017). From a management perspective, natural capital can be thought of as an evolution of the 'ecosystem services approach' which links goods and services provided by the natural world to human wellbeing. Following on from the Millennium Ecosystem Assessment (MA, 2005), four categories of ecosystem service (provisional, cultural, regulatory and supporting) are defined by the ecosystem approach that carry through to natural capital.

Whilst there are many nuanced definitions for natural capital and ecosystem services, the key distinction made by the Pioneer is that natural capital seeks to define the benefits of ecosystem services in universal terms, allowing comparison with competing priorities, be they social, economic or political.

The expectation of applying a natural capital approach is that decision makers are empowered to better understand the value of the natural environment. This is made possible by identifying and valuing natural assets, based on the ecosystem services they provide to a human population and then relaying this through to an agreed natural capital plan. Despite the availability of a natural capital framework, produced by the Natural Capital Committee, the Pioneer was required to make several assumptions of how a natural capital approach could be implemented. As the field of learning has improved, the assumptions of the Pioneer appear justified and align with current practice set by Government.

The natural capital approach must be delivered as a process. The specific approach one takes to this process is likely to be informed by project partners, the environment of interest and the aspiration for delivery. Involving stakeholders early and effectively has emerged as a key lesson to support natural capital delivery, not least because successful place-based decision making must deliver genuine benefit to the local community.

With stakeholder engagement comes a requirement for effective communication. The terminology associated with natural capital is specialised and is easily misunderstood. Simply, relatable language and supporting visual tools are a likely requirement for managers seeking to deliver natural capital planning in partnership. Enabling discussion about different value perspective through art or photography has proven highly successful as it circumvents both jargon and process.

The natural capital approach is intended to improve the sustainability of decisions regarding the environment. In doing so, it necessitates behavioural change across a broad and diverse section of society, with an understanding that a critical mass of decisions must adhere to natural capital thinking if the approach is to succeed. Success therefore is predicated on the evidence base underpinning the natural capital approach to influence decision makers.

The data required to inform a comprehensive natural capital evidence base is large and highly specific. There is a challenge in meeting this need for marine and coastal environments, despite a significant volume of relevant information existing in the public realm, as it is rarely transferable without additional processing. Uncertainty surrounding intent and scale of natural capital planning exacerbates data concerns with respect to evidence

integration and compatibility because multiple and divergent approaches are likely to manifest. In many cases, commissioning evidence will be a requirement to inform understanding of natural asset condition, ecosystem service provision and the supply of natural capital benefits. The Pioneer has developed a number of methodologies to interrogate existing data to inform this.

It is acknowledged that a natural capital evidence base need not be comprehensive, though minimum requirements are yet to be established. Experience suggests that some components are relatively more important than others and should not be overlooked. Namely, an understanding of who gains benefit from natural assets is important to inform responsibility and stewardship of assets.

Perspective is another critical element to inform evidence collection. Taking a users' perspective provides opportunity to understand intervention requirements and offers scope to improve productivity of natural environments, in terms of human benefit. Such an approach however risks environment functionality that could reduce biodiversity and increase heterogeneity and conflicts with the ambitions of the 25 Year Environment Plan. Natural capital managers are advised to consider natural capital planning from the supply, or asset perspective to understand what levels of consumption are sustainable.

Establishing a governance framework will optimise the implementation of the natural capital approach. It is a necessity to establish governance at the earliest opportunity to promote clarity and transparency amongst partners, given the need to alter decision making behaviour to affect change.

A clear distinction between governance approaches can be made between autocratic planning, where decisions are internalised within a system (e.g. asset owner, manager and decisions are all controlled in an autocratic way) and planning in partnership, where delivery is dependent on multiple parties working collaboratively. Planning in partnership is considered to be the future model. Where partnership working is complex, involves multiple parties or draws on different disciplines, the fundamentals of communication and governance become critical.

Governance and communication are paramount for delivering natural capital in partnership due to the requirement to influence all associated parties. For the majority of the decision-making processes, people favour 'rules of thumb' and are likely to be influenced by external and unobservable factors, in preference to being evidence led. Bounded rationality in decision making must therefore be assumed the norm and acknowledgement should be given to the limited capacity for evidence to dictate decision making. This underlines an absolute requirement to tailor evidence to the audience.

In terms of presenting information to decision makers, natural capital accounts and asset registers are considered best practice as they distil volumes of information into discreet packages. Summarising natural capital evidence increases the risk of misinterpretation. In certain cases, pertinent data may exist but cannot practicably be distilled into such formats. Decision makers must be made aware of the gaps in evidence in a simple way. Standard formatting is proposed to consistently identify gaps and promote information sharing.

Natural capital accounts are intended to relay environmental information to decision makers through a single, familiar unit: currency. It is possible to derive values for natural capital accounts from incomplete information. However, there is a tendency of people to make assumptions that any numbers they are presented with are accurate and representative. It is likely the majority of natural capital valuations won't accurately represent environment assets they intend to summarise, which risks undervaluing environmental goods.

For this reason, it is advocated that place-based decision making, does not exclusively view natural capital through an economic lens and that any natural capital approach retains capacity to consider values from a systems perspective. This may mandate some form of participatory approach is undertaken which allows consideration of value perspective beyond monetary. Participatory approaches have been shown to yield excellent results, in terms of evidence collection, value perspectives and for defining beneficiaries.

Suffolk Marine Pioneer & Natural Capital

Scope of the Pioneer

In 2017 the Pioneer Programme was established by government, following the advice of the Natural Capital Committee. The Programme consisted of four geographically distinct projects exploring the same objectives for different environments (urban environment (Manchester); river catchments (Cumbria); landscape (North Devon); and marine (Suffolk & North Devon). Any reference to 'the Pioneer' in this document relates solely to the Suffolk Marine Pioneer unless explicitly stated otherwise.

The aim of the Pioneer Programme was to inform the iteration and implementation of the Government's 25 Year Environment Plan that sought to 'Improve the state of the environment within a generation' (HM Government, 2018). Defra set the Pioneers four objectives, but did not specify how the Pioneer projects should approach these (Defra, 2016). These were:

1. Test new tools and methods as part of applying a natural capital approach in practice.
2. Demonstrate a joined-up, integrated approach to planning and delivery.
3. Pioneer and scale-up the use of new funding opportunities.
4. Grow our understanding of 'what works', sharing lessons and best practice.

Each Pioneer was managed by an appropriate organisation within the Department for Environment, Food and Rural Affairs (Defra). In the case of the Marine Pioneer, the Marine Management Organisation (MMO) oversaw programme delivery, with local management addressed in partnership at location. In Suffolk, the Pioneer was hosted by the Suffolk Coast & Heaths Area of Outstanding Natural Beauty (AONB) and supported by the Suffolk Marine Pioneer Steering Group (SMPSG).

The SMPSG was established in late 2016 to assist with project scoping and staff recruitment (Group SMP, 2017[1]). As the project progressed, the Steering Group's role developed to guide project ambition; provide contacts; facilitate collaboration with partners and align the Pioneer with local ambition. Delivery was progressed through a series of 'workstreams' delivered against the four Defra objectives.

An *Agile* project management style was adopted to allow the outputs to evolve to suit what was achievable. The scope, rationale and components of each workstream are set out in a separate project planning document (SMP, 2017[,2,3]).

Of the five workstreams (Table 1), 'Suffolk Salt marsh' was the most productive. This document is concerned only with the progress, experience and outputs of the Suffolk salt marsh workstream. Additional information and outputs from other workstreams can be found in Pioneer project documents and the outputs on the Suffolk Coast & Heaths AONB's website[1].

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[1] http://www.suffolkcoastandheaths.org/

Table 1: Summary of workstreams developed by the Suffolk Marine Pioneer.

Workstream	Scope	Local Interest	Key Partners
Suffolk Saltmarsh	Trial the natural capital approach for one coastal habitat.	Explore how partnerships with Defra might help unlock barriers to local delivery of habitat restoration	Cefas, University of Essex, University of Cambridge, University of Hull, Daryl Burdon Ltd. University of Aberdeen, Natural Capital Solutions, The Environment Agency, Coastal Partnership East, Natural England, River Deben Association, Suffolk Coastal Forum, Deben Estuary Partnership, Suffolk Coast & Heaths AONB
Kessingland & Benacre	Identify barriers to natural capital delivery under the current regulatory system.	Delivery multiple benefits from the realignment of at-risk coastal infrastructure.	Internal Drainage Board, New Economics Foundation, Coastal Partnership East, Environment Agency, Natural England.
Shingle Engine	Making a case for innovative approaches through applying a natural capital approach.	Deliver multiple benefits from coastal defence projects that require novel approaches to deliver within budget.	Coastal Partnership East, Suffolk County Council, The Environment Agency, University of East Anglia.
Blue Growth Lowestoft	Using natural capital arguments to bridge the funding gap between onshore and offshore renewable.	Approach parity with benefit payments made onshore to deliver better value for communities on the coast.	Plymouth Marine Laboratory, Suffolk County Council.
MPA Governance	Explore if natural capital thinking can support statutory conservation objectives.	Support statutory conservation objects under increasingly austere scenarios.	Natural England, Marine Conservation Society, Fauna & Flora International, Eastern IFCA.

Natural Capital

Natural Capital can be defined as; The elements of nature that directly or indirectly produce value to people, including ecosystems, species, freshwater, land, minerals, the air and oceans (POST, 2016). Natural capital can be thought of as an evolution of the 'ecosystem services approach' which links goods and services provided by the natural world to human wellbeing. Four categories of ecosystem service (provisional, cultural, regulatory and supporting) are defined by the ecosystem approach that carry through to natural capital (Millennium Ecosystem Assessment, 2005). Whilst there are many nuanced definitions for natural capital and ecosystem services, the key distinction made by the Pioneer is that natural capital seeks to define the benefits of ecosystem services in universal terms, allowing comparison with competing priorities, be they social, economic or political.

A natural capital approach[2] - that is applying the concept of natural capital to decision making - was proposed by the Natural Capital Committee (NCC) as a mechanism to meet the aspiration of the 25 Year Environment Plan (25YEP) by recognising the value of nature in day-to-day decision making.

The expectation of applying a natural capital approach is that decision makers are empowered to better understand the value of the natural environment. This is made possible by identifying and valuing natural assets, based on the ecosystem services they provide to a human population then relaying this through an agreed natural capital plan.

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[2] Defra Guidance (2020) Enabling a Natural Capital Approach (ENCA) actually identifies three spheres of application of natural capital: Incorporating natural capital into a policy or appraisal; natural capital accounting and; place based implementation. These definitions were not available to the Pioneer, such that the Pioneer interpreted the approach as described which in effect, encompasses the three spheres referred to in ENCA.

There are five stages in applying the natural capital approach that culminate in an agreed natural capital plan which prioritises actions & interventions for the environment that benefit people and nature. The stages were proposed in the NCC's 2017 publication 'How to do it: A Natural Capital Framework. Version 1', henceforth referred to as the '*NCC framework*' (Natural Capital Committee, 2017) These are:

1. Set a vision
2. Understand the baseline
3. Build an evidence base
4. Identify and weigh-up the options
5. Implement your chosen option(s)

For each stage this document covers: the theory of delivery; local context in which the Pioneer delivered; project outputs and key lessons, expressed across four reporting themes: Change; Governance; Method and Funding.

Assumptions

The NCC framework dictates the structure of this document, yet neither it, nor Defra specified how the natural capital approach would be implemented[3]. Without a prescribed direction of applying natural capital, the Pioneer was required to make assumptions regarding natural capital policy and implementation. These assumptions were first outlined in the Pioneer's Project Initiation Document (SMP, 2017) and have been retrospectively grouped by reporting themes in Box 1. The assumptions were informed with input from: Defra group discussions on policy opportunity; persons with sight of early drafts of the 25 Year Environment Plan and input from SMPSG partners experienced in instigating environmental change.

Box 1: Assumptions made by the Pioneer regarding the implementation of natural capital approach

Theme	Assumption
Change	I. The Government's intention is to apply a natural capital approach to improve the sustainability of decision making. Specifically, in how the natural environment is considered alongside economic and human interests. II. The government's ambition (to improve the state of the natural environment) is not currently matched by decision makers or the regulatory framework. i.e. a change is necessary. III. In instigating any change with national ambition there is a need to acknowledge and account for inertia (in accepting and implementing this change).
Governance	IV. Decision making refers to both public authority decisions (including regulatory) and business planning. The latter being inferred by the requirements of an effective, system-wide approach. V. The Natural Capital approach is not intended to offer financial compensation for environmental degradation. The risk of misinterpretation will, however, be considered by the Pioneer. VI. Clear communication is needed to maximise the potential of the Suffolk Marine Pioneer. A Natural Capital approach seeks to engage widely outside of traditional environmental management circles. Understanding and engagement from wider audiences is therefore critical to success.
Method	VII. The Marine Pioneer will act as a trial to understand how the natural environment can be considered alongside economic and human interest by applying natural capital thinking. Where successful, this learning might be applied more widely.

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[3] As of January 2020 the understanding has centred around the ENCA to meet the demands of the Environment Bill (2019).

	VIII. To maximise success, the natural capital approach should be implemented at an ecosystem scale, such that benefits, beneficiaries, and costs are kept within the system and provide feedback. Barriers exist that currently hold back this ambition.
	IX. Successful implementation of the natural capital approach at project level must be scalable to maximise value of the demonstration.
	X. Both success and failure in demonstrations are useful outputs of the Pioneer. Failure may pose risks for delivery for local projects. Risk will be communicated and minimised where possible.
Funding	XI. Traditional investment in environment benefit has been implemented at project level. Working at project level to demonstrate the concept of natural capital removes one barrier of implementation (i.e. funding).

Implications of Assumptions

The natural capital approach offers the potential to deliver environmental improvement at scale. Realising this potential is not straight forward and would necessitate changing how environmental policy is governed and delivered. Adjusting to such change presents a risk of the natural capital approach being misinterpreted or exploited. This could result in significant declines in public and environmental good that could severely undermine the rationale for taking a natural capital approach. The risk of misinterpretation is perceived to come partly from the desire to equate the natural environmental with financial accounting, which has previously incentivised environmental degradation, and partly from inaccurate implementation practices. No single, pragmatic model for delivering the natural capital approach is proposed and it was part of the role of the Pioneer to explore this.

The reporting themes of the Pioneer; Change; Governance; Method and Funding, are outlined below:

Change

Lessons reported under the 'Change' theme advocate changes to how environmental policy is realised if the natural capital approach is to be successful. In England, a drive for genuine change is recognised in the ambitions of the 25 Year Environment Plan as it advocates for environmental *enhancement* as opposed to the current rhetoric of *conservation*. The necessity for environmental policy change is evidenced in numerous studies that have documented the decline & degradation of species, habitats and ecosystems (Hayhow et al., 2019).

Where change is suggested in this report, it does not relate to changes in specific legislation or policy, rather it refers to the realities experienced by practitioners attempting to act upon current policy. Defining the precise nature of legislative or policy change is beyond the scope of this report.

Governance

The specific actors involved with natural capital planning are likely to influence the scope and outcomes of the plan in question. Governance is therefore intrinsic to the success or otherwise of the natural capital approach. Noting assumption *iv*, the Pioneer did not set out to advocate any particular governance framework.

The Pioneer was required to explore collaborative and partnership working as one of Defra's four objectives. Collaborative and partnership working can encompass many permutations that may or may not be relevant to how natural capital is implemented in England[4]; Public- Public; Public-Private; Public (government)- Public (local authority) are examples of possible partnership approaches for implementing environmental policy. In reality the complexity of partnership is likely to be far higher and involve many actors. It was not practicable to second guess if and how

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[4] The 25 Year Environment Plan sets ambitions for England only. Environmental legislature is devolved for other countries of the United Kingdom.

'partnership' would be framed by government policy, rather the Pioneer sought to ensure outputs of the project could support a broad variety of partnership approaches.

Effective partnership working breaks down boundaries and embraces the greater capacity for problem solving offered by inter-disciplinary working. Effective partnership working requires parties to shift focus from being objective driven to being driven by outcomes. Many examples could be used to illustrate the hurdles delivery organisations face in the current system that underline the importance of governance. For example. In England, Natural England and the Environment Agency share similar objectives for conserving habitats of conservation importance, such as salt marsh. Despite the commonality, their respective working practices and regulatory requirements can act to inhibit one another, particularly for proactive actions to enhance salt marsh through sediment accretion. Examples of inadvertent antagonism can be found throughout England[5].

Method

The Pioneer was established to explore how a local natural capital approach could work[6]. As such, lessons under the theme 'Method' relate to the question of 'what works' and what doesn't for each phase in the process of natural capital planning. With regard to the Pioneer's approach, assumption *viii* implies best practice would indicate that natural capital planning is conducted at an ecosystem scale. This aligns with the 25 YEP vision but this way of working is not reflected in current governance structures where partnership working at an ecosystem scale is currently the exception and not the rule. Rather than address institutional change to test natural capital at an ecosystem scale, the Pioneer sought to focus on practicable delivery by working at project level. Despite this, lessons reported under the 'Method' theme are applicable to natural capital planning processes conducted at national, ecosystem, and local level, unless stated otherwise.

Funding

The Pioneer was conceived following a period of government austerity that oversaw cuts to public sector services and environmental stewardship. The requirement for the project to explore novel funding opportunities, including from the private sector indicated a need to source revenue to fund natural capital implementation. Lessons under the theme of 'Funding' relate to financial lessons, both from the perspective of natural capital accounting and for the resource required for delivery.

This document is intended to inform a wide and diverse audience of practitioners. As a consequence of this it was not possible to state a prescribed course of action for each reported lesson and so requires interpretation by the reader. The exception to this is the 'application' section of the evidence commissions, to be found in the technical annex. This section identifies specific opportunities to apply methods and processes developed under the Pioneer to policy and decision making.

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[5] Beneficial re use – REACH.
[6] The term 'Place based' has become common when describing local application of natural capital. The Government's Enabling a Natural Capital Approach guidance offers additional insight.

The following sections report on the Pioneer's experience against the framework approach to natural capital, set by the Natural Capital Committee. This framework outlines the five stages of developing a natural capital plan which are conceptualised in Figure 1. For each stage of the framework, this document outlines theoretical outcomes; provides the context of project delivery; details the Pioneer's experiences and concludes with key lessons.

The focus of this document is the *Suffolk salt marsh* workstream of the Pioneer (Table 1). Unless explicitly stated otherwise all references are made to the Pioneer's experience of developing and delivering a natural capital approach for estuarine salt marsh in the Suffolk estuaries.
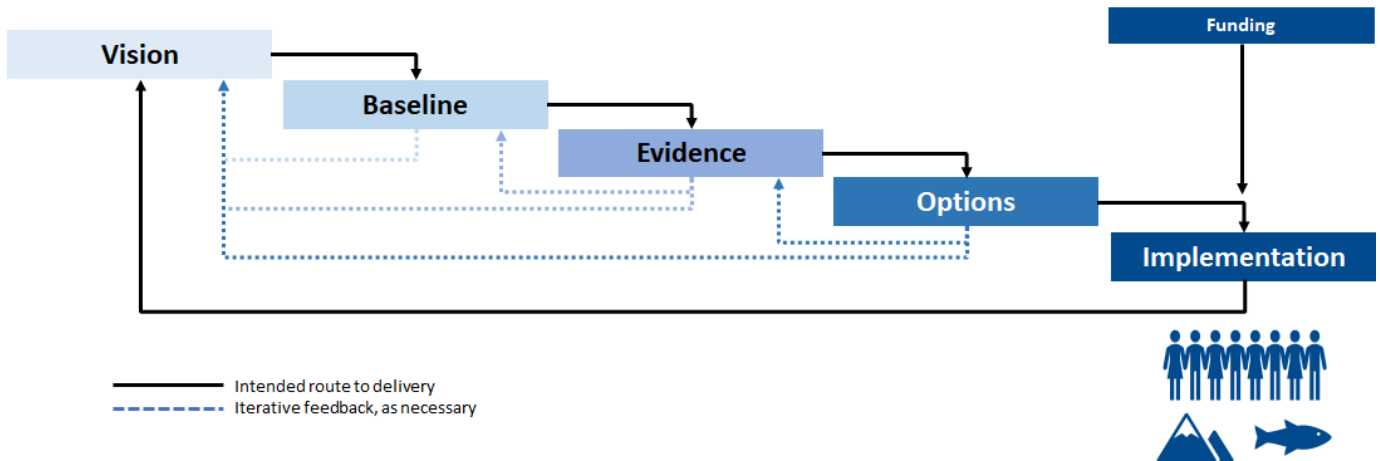

Figure 1 Adapted from the NCC framework, illustrates the theoretical development cycle of the natural capital planning process that delivers for people and the environment. Progress through the cycle is shown in solid black lines. The natural capital planning cycle is completed with the evaluation of an implemented plan, with learning informing future iterations of the plan. The NCC framework indicates there is scope for iterative development of a natural capital plan based on information obtained at a later stage (indicated by dotted lines). The framework underlines the importance of evidence in plan development as a central pillar in the process.

A Natural Capital Approach for Suffolk Salt Marsh

Stage 1: Setting a Vision

Theory

A vison sets a high-level goal that partners can unite around. The vision should act to engage, inspire and involve stakeholders to support the development and implementation of a natural capital plan. This stage of the natural capital approach can help develop aims of the plan by providing an early exploration into the issues to be addressed (Natural Capital Committee, 2017). The expected outcome of this stage is a draft list of general goals for the plan. It is acknowledged that these goals will need to be revisited and revised as the plan develops.

Context

Suffolk has five estuaries that include expanses of established salt marsh: the Deben, the Alde & Ore, the Stour and the Orwell, as well as the Blyth. Management groups for each estuary formed following public consultation on the first shoreline management planning process. Composition of the groups differs but each included community, business and regulatory interests, with the latter a common presence across all. The role and purpose of the estuary management groups adapted over time. All however share a common goal to ensure management of the Suffolk estuaries is influenced by local representation to 'deliver sense of place'.

The importance of salt marsh in defining estuarine character is widely recognised by the community, business and individuals. Estuary groups hold common ambition to preserve, maintain and enhance the condition of the salt marsh, relative to historic records. Despite this ambition, frustration concerning a lack of empowerment is evident, Thomas & Cosgrove (2019).

This groundswell of support and drive to action was instrumental in defining the Pioneer's Suffolk Salt marsh Workstream. Critical to the delivery of this workstream was the coalescence of estuary group interests in early 2017, through the 'Suffolk Salt marsh Group' (SSG). SSG was tasked with addressing common estuary issues in a strategic manner, particularly around: regulation, planning, monitoring and material sourcing. The partnership approach of the Suffolk Salt marsh Group's gave rise to the Pioneer's vision to fulfil the first stage of the natural capital approach.

The Suffolk Pioneer's Vision:

> *'To preserve and where practicable, enhance the extent and condition of the*
> *salt marsh to match historic records.'*

Experience & Outputs

It is necessary to state that the Pioneer did little to influence the framing of the vision for *Suffolk salt marsh*. Rather, it formed organically across several months of the community discussing possible options to address the degrading salt marsh. The natural capital perspective that the Pioneer brought helped with cohesion across community groups as the aspiration to value natural capital assets framed change positively for people and the environment.

From a resource perspective, the Pioneer was fortunate that the project didn't need to invest in facilitating vision discussions, instead it was able to passively absorb an understanding of local aspiration over an extended period of time. The ability to dedicate time to passive engagement is unusual in a project context but was effectively mandated due to an embargo on public communication of the Pioneer[7]. It is unlikely that this approach would be widely adopted

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[7] External communications concerning the Pioneer were embargoed prior to the 25 Year Plan's publication. This approach was not intentionally, rather it occurred as a consequence of political upheaval that delayed publication.

because of the time dedicated to engagement. However, understanding the community aspiration through stakeholder engagement should be noted as good practice. Inclusive and early engagement is recommended to develop a robust vision. Indeed, the Pioneer's experience, both in Suffolk and North Devon[8] supports the argument for natural capital managers to co-develop visions with their stakeholders, rather than seek to drive outside agenda. This stands regardless of ambition or governance structure as there will be a need to work with communities when implementing a natural capital approach.

In engaging the public with natural capital, the need for effective communication is paramount. Natural capital is a complex concept to articulate and one that is often poorly understood. The Pioneer used the term *natural capital* sparingly in public engagement, opting instead to use terms such as 'nature's value' and 'natural products'.

This strategy worked well for informal discussion but was ineffective for situations that required greater detail. To address the challenges around wider engagement, the Pioneer chose to tackle the communication challenge visually using photography. Specifically, the Pioneer invited members of the public to define nature's value by submitting a photograph of the natural environment with an accompanying caption. Guidance on the captions was given around the four categories of ecosystem service to help steer submissions away from 'pretty natural photographs' towards relatable images that the Pioneer could start an engaging conversation with. Some examples of these are available in Annex 1[9]. The images were found to be a highly effective visual aid that facilitated rapid and in-depth discussion relative to other means of communicating the concept. Additionally, they were useful in mediating discussion between stakeholders as they provided common ground for even diametrically opposing views.

Reflecting on the theory of natural capital visioning, the organic development of the Pioneer's vision was influential in ensuring the output involved and inspired stakeholders. A well-constructed vision should be deliverable. Natural capital managers should therefore consider the criteria by which they can evaluate the vision to ensure it is fit for purpose. This may be achieved by taking a project management perspective, particularly with regard to the **S**pecific; **M**easurable; **A**ssignable; **R**elevant; **T**imely mnemonic.

For the Suffolk Marine Pioneer, the focus of the vision derived from community interest and individual perceptions of which natural asset(s) required improvement. Similar participatory approaches were taken by the North Devon Marine, the Devon Landscape, and Cumbria Catchment Pioneers, with each deriving visions through stakeholder input. In developing a vision with community input, the risk of misalignment between community and ecological priorities exists where understanding of natural capital is imperfect. This is heightened where participation is limited or restricted. To mitigate this risk, it becomes imperative for natural capital managers to evaluate how the visioning process is facilitated.

For the Pioneer's Suffolk salt marsh vision the most recent Site of Special Scientific Interest (SSSI) condition assessments were reviewed for the Deben estuary. These identified 77% of salt marsh as 'unfavourable, declining' (Natural England, 2020), indicating that community desire to improve salt marsh was matched to an empirically defined condition.

Key learning: Setting a Vision

Change

- A natural capital vision need not be a 'new' vision. Stakeholders often have long held ambition to improve the places in which they live and work, natural capital offers a route to deliver this and may not necessarily alter the outputs sought.

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[8] The North Devon Marine Natural Capital plan and references within detail the Devon marine Pioneer's experience regarding engagement. https://www.northdevonbiosphere.org.uk/mncp.html

[9] Outputs of the 'Nature's Value' Photography Competition are available in Annex 1

- Where novel concept or aspiration is sought, natural capital managers should instil trust and so, build support by holding transparent and open discussion.
- Communicating the concept and intentions of the natural capital approach is challenging but critical. Natural capital managers should consider their communication methods based on their intended audience and the relative depth of discussion.

Method

- It is important to understand local ambition to engage, inspire and involve residents and business.
- Early, broad and inclusive stakeholder engagement is recommended when developing a natural capital vision. Engaging and listening to stakeholders will act to instil trust in the process and facilitate wider support for natural capital planning.
- When engaging publicly on the subject of natural capital, simple, relatable language should be used in preference to technical jargon. Natural capital managers should remember that people may relate personally to the natural environment at a level incompatible with natural capital planning. Where such discrepancies exist, the risks of reduced support and limited stakeholder buy-in to the vision should be recognised.
- When conducting and revisiting the visioning process, it is useful to have some form of evaluation framework in place to ensure the vision is still fit for purpose. Rather than a separate formal process, this may be facilitated by ongoing meetings and discussions. Evaluating against, for example, the **S**pecific **M**easurable **A**ssignable **R**elevant **T**imely mnemonic, will remove any ambiguity in the visioning process where governance has not properly been defined.

Governance

- Natural capital partnership approaches require diverse stakeholder support to succeed. The visioning process is a critical first step in attaining this support.
- The frameworks and organisations set up to govern the natural capital plan development and implementation have the potential to influence the direction of the vision. Where planning in partnership or implementing change locally, natural capital managers should be clear and transparent about governance structures so as not to undermine partner confidence.

Funding

- Visioning provides the foundation for a natural capital approach and so should not be under-resourced, particularly where novelty or significant change is sought.

Stage 2: Understanding the Baseline

Theory

Stage two in delivering the natural capital approach is to understand the starting position relative to the vision. Baselining ensures that basic information concerning the area's natural capital is gathered, documented, and synthesised. This information will include details of current management in addition to ecological and physical understanding of natural assets. Gathering this information should provide the basis for analysing how to achieve the goals set by the vision. It is at this stage where technical knowledge of ecosystem services becomes useful to natural capital managers.

The NCC framework states a baseline should identify the state and condition of natural capital assets and identify the ecosystem services provided by the assets[10]. Additionally, it may build upon understanding of risks to assets and the drivers of change. It is acknowledged that this information may already exist in current plans, management strategies or as spatial data. Baselining will collate, and where necessary, aggregate data. In so doing it will identify knowledge gaps that can be addressed in Stage 3.

Context

Under commission from Defra in May 2017, Eftec and ABPmer produced a *Baseline Assessment* for the two Marine Pioneer project sites: North Devon and Suffolk. This work was delivered in the form of two separate reports, though only the report for the Suffolk Marine Pioneer (Frost & Dewey, 2017) is relevant here. The timing of this report was significant in that Frost and Dewey (2017) required defined project boundaries to process spatial data. This request was however made before the Pioneer agreed spatial boundaries so required Frost and Dewey to define an arbitrary boundary, shown in Figure 1. This was based upon:

- A focus on the Suffolk Coast & Heaths AONB, as hosts to the Suffolk Marine Pioneer project.
- The Water Framework Directive (2000/60/EC) seaward extent to define the marine boundary – this is roughly one nautical mile from the shoreline
- The urban landscapes of Lowestoft and Harwich to define transverse extents and a landward boundary, roughly 1km landward of AONB designation.
- Zone 3 flood risk boundary or tidal limit of estuaries based on the furthest extent inland to define relevance of estuaries.

Figure 2: Map of the Suffolk Marine Pioneer boundary, as proposed by Frost & Dewey (2017).

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[10] For the Pioneer, salt marsh is the natural capital asset. The ecosystem services are identified in Figure 4.

The Baseline Assessment conducted by Frost and Dewey (2017) informed:

a) Land-use cover
b) Stock of the physical natural assets
c) The status and location of designated sites
d) Recreational access and opportunity
e) The economic benefits of identified natural assets in the boundary area (where possible)

The Baseline Assessment mapped the extent of priority and protected habitats, including salt marsh, but was unable to identify specific habitat condition. Neither was it able to inform how ecosystem services related to specific assets as it could only consider assets homogenously in line with UK National Ecosystem Assessment habitat types (Marine, Coastal etc).

The Baseline Assessment shortlisted interventions that could plausibly deliver environmental improvement. These were informed by a review of national and regional plans. Notably, the baseline Assessment identified the restoration of salt marsh as a net gain opportunity, in doing so it supported the vision for Suffolk salt marsh.

The Baseline Assessment's relative focus on the terrestrial and coastal environment over the marine indicated by Figure 2 is indicative of the limited data available for the marine space.
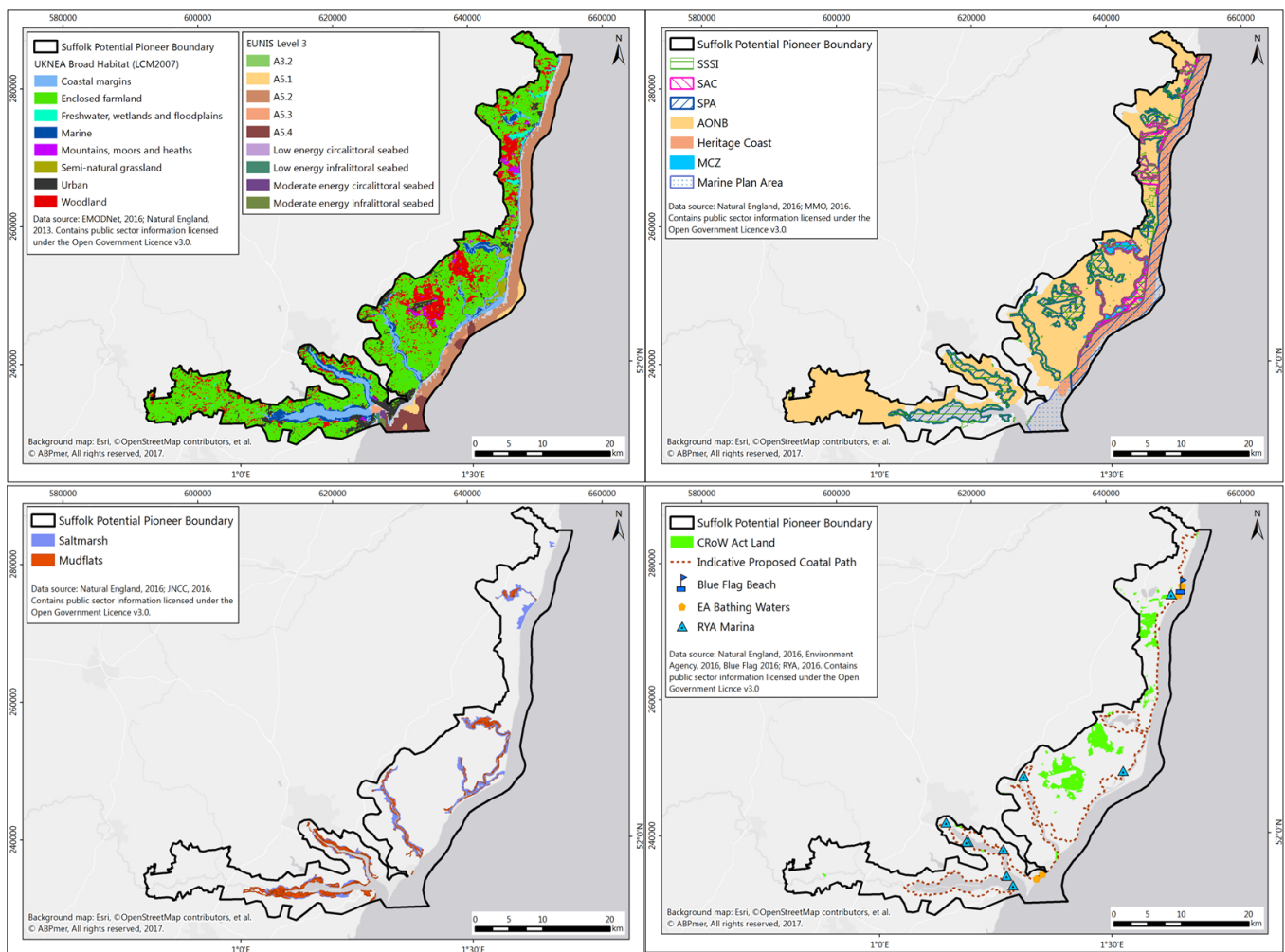

Figure 2: Selected outputs of Frost & Dewey (2017) shown as a Geographic Information System (GIS) output. From Top left: Broad scale habitat; Designated sites; Mudflats and salt marsh; Features Supporting Recreation. ESRI Openstreet map, produced by Frost & Dewey (2017).

Experience & Outputs

The value of the Frost and Dewey (2017) report was limited with respect to the vision for Suffolk salt marsh. This was partly as the vision considered a more specific geography, but also because the process of visioning helped define what was required of a baseline that could not have been foreseen when the assessment was produced. It demonstrated that an asset specific baseline was required.

The outputs of the Baseline Assessment (Figure 3) drew from publicly available data, largely produced and managed by Defra organisations. Limited attention was given to locally held data or management strategies. Following a review of the Frost and Dewey (2017) assessment by the Pioneer, it was decided to explore what additional information was held locally to advise a more informative baseline. Following this, evidence gaps and priorities for addressing gaps could be determined.

The knowledge within the Suffolk Pioneer Steering Group was invaluable to locate pertinent information. Notable information libraries included those of the estuary management groups and that of the Suffolk Coast & Heaths AONB. The latter had been compiled as a consequence of the AONB's role in coordinating activities across the estuaries[11]. Similar to the experiences of Frost and Dewey (2017), the Pioneer found amalgamating information that had originally been collected for a variety of different purposes into an informative natural capital evidence base presented challenges. Natural capital managers should not underestimate the resource required for collating a baseline.

Once collated, it became apparent that presenting the information to be manipulated and analysed in a similar manner to the Baseline Assessment (I.e. GIS Workspace) was beyond the Pioneer's resource. As such, the Pioneer's baseline should be considered 'aggregated'[12]. Box 2 summarises the baseline for Suffolk salt marsh.

Box 2. Summation of the Suffolk Marine Pioneer's baseline

Asset Extent – Annex six of the NCC framework provides a compendium of available data that may be used to determine natural capital assets. Included within this is Natural England's Priority Habitat Inventory. This is a UK wide, spatial dataset that describes the geographic extent of habitats of principal importance, including salt marsh, as listed in Section 41 of the Natural Environment and Rural Communities Act (2006). More specifically for the Suffolk estuaries, salt marsh extent is freely available as polygon data for all coastal and transitional waterbodies in England. Extent is defined from aerial imagery to a resolution of $100cm^2$ and the 2014 data is publicly available via https://environment.data.gov.uk/.

Asset Condition – Information on the condition of salt marsh within the Suffolk estuaries was available in the form of National Vegetation Surveys, though this could not be spatially mapped without extensive transposition into GIS.

Existing Plans – Deben Estuary Plan, Alde and Ore Estuary Plan, AONB Management Plan, Deben SPA Conservation Advice package, Site Improvement Plan for Deben Estuary, EIFCA Byelaws 8,12 15. Suffolk Salt marsh Group.

Trends – The salt marsh of Suffolk estuaries has been declining for the past 30 years, relative to historic records (Table A). The primary drivers of decline are debated locally but it is agreed coastal squeeze is a factor.

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[11] The AONB provided effective facilitation and in some cases coordination of estuary activities that greatly supported positive environmental action. This was delivered by partnership funding.

[12] The Baseline for Suffolk salt marsh is held locally on Suffolk county council servers. It is not included within this document but is accessible on request. Please contact schaonb@suffolk.gov.uk

Estuary[13]	Total salt marsh area (ha) 2006[14]	Total salt marsh area (ha) 1998	Net change 1971-1998 (ha lost)
River Alde/Ore	334	257	8
River Deben	325	241	71
River Stour	196	107	157
River Blyth	73	63	5
River Orwell	74	54	46
Total	1002	822	287

Risks – Coastal Squeeze effects 73% of Suffolk marshes (precipitated by climate change, and sea level rise),
- [15]Public/recreational disturbance, operational works impacting sediment budgets.

Opportunity – Restoration and improvement opportunities for salt marsh have been identified across multiple estuaries. A record of completed and planned works is available in the Suffolk Coast & Heaths Salt marsh Project register.

Land/seabed ownership – Crown Estate, National Trust, Fairways Committees, multiple private interests.

The process of developing the baseline informed a wider understanding of the geography of the Suffolk estuaries, helping the Pioneer to:

- Understand that the politics of partners pose a risk to natural capital delivery, despite commitments to work in partnership.
- Gain insight into the relative stability of salt marsh on each estuary (informed by Table A).
- Identify that many proposed interventions with community support were untested.
- Refine focus of the Suffolk Salt marsh workstream from a geography spanning five estuaries to the Deben estuary.
- Identify willingness of partners, managers and collaborators to progress the natural capital approach.

Despite this success, the baseline failed to meet several expectations of this stage of the natural capital planning process. This failure acts to identify key gaps in understanding relative to the Natural Capital Committee's expectation. In establishing a baseline, the Pioneer was ill-informed to:

- Provide investor confidence for funding natural capital interventions in the natural assets in question.
- Understand the condition of natural assets, in terms of biological functioning nor ecosystem service provision.
- Define boundaries through institutional geography. This challenge may relate specifically to marine natural capital where national marine and coastal governance is not bound to institutional geography so tightly as it is on land. The boundary of the Pioneer became defined through evidence availability and willingness to participate rather than an agreed (geographic or governance) structure. As such, this introduced an element of fluidity to the project.

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[13] Boyes & Thomson (2011),
[14] Suffolk Biodiversity Information Services, (2007)
[15] Grilli et al (2019) & Hughes (2004)

The NCC Framework states: "*At the end of Stage 2, it will be clear what the current state of natural assets is, what is currently planned for them, by whom and over what scales of space and time*." The Pioneer's experience is that this expectation is not always met by the baselining process suggesting:

- There is a challenge in transforming current data to meet the expectations of a natural capital approach for marine and coastal environments.
- Baselining a natural capital approach for the marine environment is difficult. The gravity of this should be reflected upon if the Government anticipates the natural capital approach to be ubiquitous across decision making. Data management is critical to scaling success as individual user needs will need to be met but data will also need to be collated to inform regional and national action.
- Natural capital managers should adjust expectations of what baselining can reasonably accomplish or examine other approaches for data collection.

Remote sensing techniques have increasingly been employed in scientific research and monitoring programmes as technology has improved. The ability of remote sensing tools to rapidly and consistently collect data across a wide geography offers efficient data collection and therefore an attractive proposition for natural capital managers seeking to baseline understanding.

A pilot project exploring the ability of remote sensing tools to link features of salt marsh to natural capital benefits ran on the Wash, Norfolk, concurrent with the Pioneer (Lew et. al., 2018). Though successful in applying remote sensing to identify sub-features, the project was unable to verify natural capital benefits against stakeholder expectation. The pace of development may soon advance to enable remote sensing to inform a natural capital baseline, but the outputs of this work suggested remote sensing techniques do not shortcut investment in baselining.

Key Learning: Establishing a Baseline

Change

- Datasets are often segmented by political boundaries. This can pose challenges for baselining of assets that straddle multiple jurisdictions as obtaining a complete dataset may become resource intensive.
- Data management is expected to be critical. It is expected that there will necessarily be multiple approaches to baselining to match user needs. To inform national policy objectives these likely divergent approaches will need to be made sense of centrally.

Governance

- Baselining is unlikely to definitively identify where and how resource should be allocated when building an evidence base. Natural capital managers should be aware that this lack of certainty leaves scope for bias to influence how the evidence base is developed and resourced. Establishing protocols around how decisions are made and by whom will mitigate this risk and support the vision. This issue is most likely to manifest where exploitation of natural resource is possible.

Methods

- Baselining must be specifically matched to meet the scale and focus of the vision. A bespoke baselining exercise may not be necessary where suitable information exists already. Obtaining clarification of this information is not a straightforward task, as noted under 'change'.
- Place based natural capital approaches cannot solely be informed by baselining conducted a broader scale.

- Local and partnership led approaches offer great potential for developing baselines. Incorporating some mechanism to include 'bottom up' data collection is strongly advised to ensure informative and contextualised Baseline Assessments. This finding was consistent across the Pioneer Programme.
- A baselining exercise that offers relevance at different management scales can usefully inform routes to implementation and impact.
- Clarity of understanding precisely what type of information is necessary to usefully inform a natural capital baseline can improve the efficiency of the baselining process. Many publicly available datasets are poorly suited to informing natural capital evidence (concerning provision and sustainability of ecosystem services) without additional processing.
- Aggregating a baseline into a GIS (or similar) tool is not strictly necessary to inform natural capital planning. However, digitally aggregating and georeferencing data greatly benefits communicating the process and supports decision making and future evaluation.
- Socio-political information should be considered as part of any baselining exercise in addition to physical and ecological data as this information informs implementation opportunities. This underlines the need for place-based approaches.
- It is difficult to define when the task of baselining should be considered complete and when to continue developing the evidence base as the two tasks may overlap or run concurrently. This is likely to be determined on a case by case basis, influenced by resource, timescale, data availability and stakeholder input. It is advisable to consider this question early on in the process to ensure effective integration of data and an order of development that can self-seed.
- Notwithstanding the need to assess at an appropriate scale, consideration should be given to the value of recent assessments. It is conceivable that a large proportion of baseline information one is seeking has already been meaningfully collated through another process. For example, marine planning processes may hold value.

Funding

- Unless significant resource is committed, conducting a baselining exercise is unlikely to yield an understanding of marine natural asset condition. This requires new approaches (such as the Pioneer developed with the University of Essex - see Box 3-6 in the technical annex) to define asset condition relative to ecosystem service provision.
- Resource required for data processing and formatting should be considered a critical component of the baselining process. Disparate data held under differing management processes are not straight forward to collate. This makes a case for common standards or processes that can be adapted to suit place specifics.

Stage 3: Build an Evidence Base

Theory

It is necessary to understand the extent and condition of natural capital assets, ecosystem services and their associated benefits to inform natural capital planning. Developing an evidence base will inform how this can be achieved but require significant and specialist resources. The output of this third stage should be a series of potential plans where inputs, outcomes and beneficiaries are identified.

The NCC framework advocates building an 'asset register' to understand what the components of the environment are. Then compose a 'risk register' to inform planning and priorities. The asset and risk registers are intended to work in the same manner as their equivalents do in accounting, in that they evidence decisions regarding how to progress the desired trajectory for a specific asset. It is acknowledged in the NCC framework that neither the asset nor risk registers need be comprehensive before they can inform decision making[16].

Information held in asset registers is required to capture the state of the environment and so must accommodate the different units of expression for: users, condition, managers, quantities and ecosystem services. The Natural Capital approach identifies the development of natural capital accounts as the panacea to address environmental degradation by expressing the values of assets in comparable terms (likely monetary). Natural capital accounts are expected to be most useful when they can capture change over time as opposed to offering insight into a single point in time.

Context

With reference to the above, the Pioneer acknowledged that an evidence base is required to serve two objectives:

1) Inform natural capital plan development, as illustrated by Figure 2.

2) Evidence valuations of assets to inform natural capital accounting and so influence *better* decision making (HM Government, 2018).

The first point relates to the development of a natural capital plan, with the second referring to how the plan will take effect over its lifespan. This implies that the evidence base is required to influence across an extended timescale. The requirement to influence puts people at the heart of the natural capital approach on the basis that individuals will be taking decisions. Tailoring the evidence to meet the needs of those developing and using the plan is likely to deliver a more effective result because it will support user understanding. It is useful to review the plan development process in order to understand where opportunities to tailor the evidence to meet user needs might occur (Figure 5).

Evidence Dependencies

Opportunities to tailor the evidence to user needs are not restricted to understanding the process. The construction of the evidence base itself also provides routes to ensure influence. This becomes apparent when the complexity of a natural capital evidence base is revealed. Figure 1 depicts *evidence* as a single entity. This is however misleading as a natural capital evidence base is constructed of many components of understanding. These are outlined in Table 2. The components of the evidence base are often interdependent. To progress understanding of a component of the evidence base might first require a comprehensive knowledge of another component. For example, it is not possible to quantify ecosystem service provision without first having an understanding of the extent and condition of a natural asset. Such interdependencies require a natural capital evidence base to be constructed sequentially.

Figure 4 illustrates the broad dependencies of a natural capital evidence base and the communication barriers between them. For terrestrial habitats, provision of ecosystem services is correlated with the extent and condition of the natural assets[17]. For example, the extent and type of trees in a woodland will determine quantity of timber

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[16] Some components of evidence are likely to be critical. An understanding of who benefits has been found to be highly important in the case of the Pioneer.

[17]

production. This relationship is often more complex in the marine environment, where provision of ecosystem service may be more closely correlated with natural processes and ecosystem functionality, e.g. Upwellings of cool, nutrient-rich water that support primary productivity and support fisheries.

When determining which components of evidence should be sequenced first, it is important to consider perspective. It is possible to start either from the user's perspective, in terms of what benefits are sought from the environment, or from the asset perspective (Figure 4). The former works 'backwards' from the needs of the user to determine the optimal environmental conditions required to meet the service demand required; whilst the latter seeks to understand what benefits are available from the current (or improved) environmental condition. In approaching the evidence base for the Suffolk salt marsh, the Pioneer chose not to consider the user's perspective on the grounds that it promotes a utilitarian natural environment by adapting the environment to suit demand, rather than adjusting or reducing demand to match supply. This approach risks exceeding the capacity of the environment to sustain benefit that could reduce biodiversity and increased heterogeneity (Temel et al, 2018, Millennium Ecosystem Assessment, 2005), an outcome that conflicts with the ambitions of the 25 Year Environment Plan.

A wealth of literature underpins natural capital thinking, such that it is possible to understand the broadscale relationships between natural asset and ecosystem service provision from the literature alone. For the marine and coastal environments the summaries of Natural England in (2012) and the UK National Ecosystem Assessment[18] in 2014 are particularly useful. This baseline was developed by Potts et al., (2014) and then Burdon et al (2017) into an accessible matrix format. Where evidence is required to reliably inform decision making, it may be necessary to develop a more specific understanding than that available in the literature. For example, a more accurate or updated appraisal of ecosystem services may be required for specific assets, especially if significant change (in environment or use) has occurred. This may require bespoke analysis and/or the need to undertake field research.
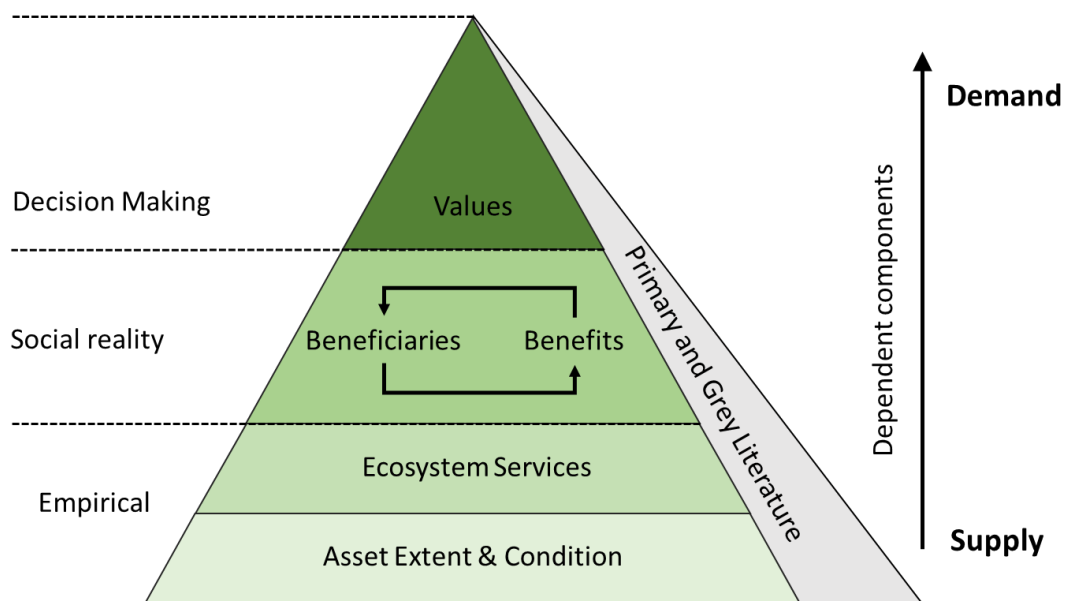

Figure 4: Component parts of a natural capital evidence base, structured by relative dependency. The schematic identifies three lenses through which the evidence base may be seen; Empirically, in the context of social reality and from a decision-making perspective. Communicating across these perspectives is known to be challenging but is a pre-requisite of an informative natural capital evidence base. Evidence components shown in the pyramid are considered contingent on underlying components. It is possible to address the challenge of communicating evidence

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[18] The UK National Ecosystem Assessment (2011/2014) provides a national baseline for the UK

by working logically 'down' or 'up' the pyramid. Literature exists that may inform all components of evidence, dependent on the expectations of planning.

Bringing logical order to the development of an evidence base is useful, but it does not guarantee effectiveness. To understand effectiveness requires an appreciation of the intended audience(s) and how they will use the evidence to affect decision making.

In the case of the Suffolk Marine Pioneer, the intended audience for the evidence base are those organisations who make decisions affecting the Suffolk estuaries. As such, the evidence base for the Suffolk Pioneer is required to bridge empirical, social and decision lenses (Figure 4) for the organisations listed in, but not limited to, Table 3.

Table 3: A non-exhaustive list of organisations with relevant decision-making powers in respect of the Pioneer's Vision for Suffolk Salt marsh.

Responsible Organisation	Relevant Decision(s)
The Environment Agency	Coastal flood risk management
Natural England	Conservation of designated areas
The Marine Management Organisation	Marine licensing
Suffolk County Council	Transport infrastructure, waste disposal, strategic planning
Suffolk Coast & Heaths Area of Outstanding Natural Beauty	Management planning
The National Trust	Land management
East Suffolk Council	Residential planning
Deben Estuary Partnership	Estuary management planning
Department for Environment, Food and Rural Affairs	Environmental policy direction
Crown Estate	Seabed use leasing
EDF Energy	Development, maintenance and running of Sizewell nuclear power station.
Hutchinson's Ports (Felixstowe Port)	Port management planning
HM Government and it's departments	National policy
New Anglia Local Enterprise Partnership	Regional development

Governance and Decision Making

Another consideration in developing a natural capital evidence base is governance. Governance affects the audience of the evidence base. Governance can be defined as the interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens and other stakeholders have their say (Lockwood et al., 2010).

Defra established the Pioneer on the advice of the Natural Capital Committee to inform the implementation of the Government's 25 Year Environment Plan. Though the Pioneer was tasked with testing a natural capital approach, the necessary components, personnel and governance structures to achieve were not established when the Pioneer became operational. This necessitated governance to be tested concurrently with Pioneer project delivery.

To date, no published guidance on what constitutes good governance for natural capital planning and delivery exists[19]. Despite this, some fundamental considerations are becoming apparent. Notably, it is critical to distinguish between autocratic planning approaches that are internalised within a system (e.g. asset owner, manager and decisions are all controlled in an autocratic way) and planning in partnership, where outputs are dependent on multiple parties. Clarifying which approach is being used will inform how circuitous decision-making is likely to be during plan

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[19] The question of governance has been tackled by the Pioneer projects located in North Devon.

development and implementation. It also identifies the relative need for the components of the evidence base to be comprehensible to a wide audience.

Planning in partnership necessitates that supporting evidence be sufficiently informative to instil confidence in all partners. For natural capital managers planning autocratically, the evidence base need only meet their personal requirements.

Securing confidence in evidence is often associated with a higher cost, therefore natural capital managers are faced with an inherent trade-off between comprehensibility and coverage (Brick et al., 2018). It is likely that a decision will be influenced by factors other than evidence (resource, opportunity and risk). The risks associated with decision makers discounting the evidence base underlines the importance of establishing core governance structures early in the natural capital planning process.

Establishing governance in advance of constructing an evidence base supports the ability of natural capital managers to tailor the evidence base to better meet user requirements. Figure 5 underlines the importance of establishing governance structures early through identifying the points in plan development where partners may influence the direction of the natural capital planning process.

For the Pioneer, the lack of established governance and resulting lack of stakeholder knowledge meant the Pioneer was unable to tailor the scope of its evidence base to meet specific user requirements. This required the Pioneer develop a robust evidence base to instil confidence in as many organisations as possible. As a consequence, the Pioneer's evidence base traded comprehension in favour of coverage. This decision was taken with the expectation of delivering the natural capital approach with limited available funding (Defra 2016) mandating a need to generate external investment. This expectation requires evidence to be sufficiently robust to stand up to investor scrutiny, hence the need for high confidence.
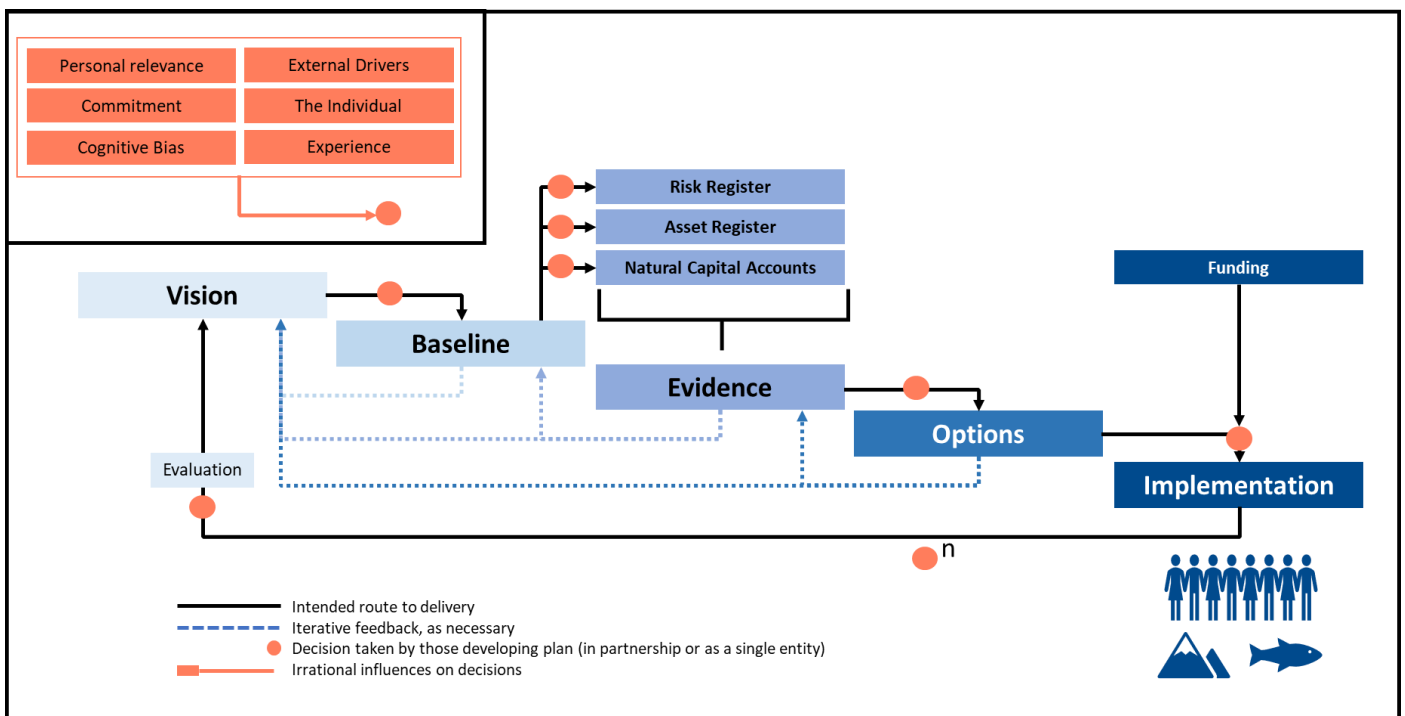

Figure 5 Expanded schematic of the natural capital planning process that include external drivers to decision making and the subsequent decision waypoints in the process. The decision points identify where evidence may or may not

be influential. Informed by cognitive psychology (Juliusson et al., (2005), Stanovich & West (2008), de Bruin et al., (2007), Acevedo & Krueger, (2004) and Dietrich (2010).

The question of how a natural capital evidence base is expected to influence decision making is yet to be addressed in this report. The literature produced by the Natural Capital Committee gives little consideration to how a natural capital evidence base is expected to influence decision making. Instead, it asserts that the framework provides support to:

"help decision makers protect and improve their natural environment".

This statement implies support for natural capital planning is implicit in all relevant actors or that obtaining support is simply a matter of course. In not addressing the pathways to influence, the NCC Framework assumes that decision makers and those implementing the decisions will behave rationally by accounting for the evidence base in a consistent manner.

The experience in Suffolk is that there is no guarantee that evidence will influence rational action, hence references to external influences in Figure 5. The current state of the environment is the consequence of external (often not evidenced based) drivers influencing decision making. The status quo is suggestive that natural capital evidence is unlikely to exert immediate and overriding influence on decision making. Numerous empirical studies have indicated rational choice might be a poor guide for environmental economics, especially where social drivers are not considered (OECD,2012 2017a and 2017b).

It is acknowledged that when making decisions, people are often concerned with unobservable interests (context, reputation, fairness etc). Taking the necessary time to understand the optimum pathway is uncommon practice in the majority of decision-making processes. Instead, rules of thumb are commonly employed. These factors compound to deliver irrational decision making (OECD, 2012) which natural capital managers must assume to be the norm when developing a natural capital approach. This issue has relevance during plan implementation but may influence the decision points indicated in Figure 5.

Experience & Outputs

Natural capital accounts, a risk register and an asset register, tailored for the appropriate audience(s) are the foundations of the evidence base required to reliably inform a natural capital approach. In this document, individual components of the evidence base will be referred to where explicitly relevant, however the term 'evidence base' will be more commonly used as a collective and generic term.

Critical to the assumptions made by the Pioneer (Box 1) is the need to deliver the natural capital approach with limited funding. Evidence generated to support the natural capital approach must therefore be: affordable, scalable and transferable. These requirements add to the need for evidence to be clearly communicable and tailored for relevant audiences, as discussed previously. The Pioneer sought to develop understanding through analysing existing datasets rather than commissioning bespoke data.

According to the NCC framework, a comprehensive natural capital evidence base includes the following components:

- The physical extent and condition of assets
- The ecosystem services provided by the assets
- The benefits afforded by these services
- The state and stability (risk to) of assets, stocks and services
- Those benefiting from the assets, stocks and services

Table 2: The components of a natural capital evidence base. Informed by Natural Capital Committee (2017)

Component of evidence	Asset Register	Risk Register	Natural Capital Accounts
Asset extent	X		X
Asset condition	X		X
Ecosystem services	X		X
Natural Capital benefits derived from ES.	X		X
Relationship between ecosystem services and benefits	X		X
Landowners and managers	X		X
The human beneficiaries		X	X
Probability of change		X	
Scale of impacts from change		X	
Risks to assets		X	
Risks to deriving benefits		X	
Private value of assets			X
Public values of services			X

Key Gaps

The level of detail required to inform the evidence base will be determined by the expected outcomes and the requirements of monitoring and evaluation. The Pioneer was established as a test-bed for the natural capital approach and not therefore compelled to limit data collection to meet any prescribed criteria. This permitted a freedom for the Pioneer to consider the analytical question of: What evidence is necessary to inform decision making?

This section provides only a brief summary of the Pioneer's approach to developing evidence. For each component, a dedicated summary is included in the technical annex, appended to this report. The technical annex includes information on: evidence requirements, available information, gaps, solutions, methods, and potential applications and represents a summary of complete technical reports. All technical reports have been made available online via the Suffolk Coast & Heaths webpages.

The most pressing gap identified through the process of baselining and that could not be addressed by wider literature review was an understanding of the condition of the salt marsh. This was addressed using research from the University of Essex (Green et al. 2009, 2012, Slee et al. (2018), Legge et al. (2020)) and is summarised in Box 3 of the technical annex.

Figure 6 maps the Pioneer's approach to quantifying ecosystem service provision of Suffolk salt marsh over the logic of ecosystem service delivery, originally outlined in the national ecosystem assessment. Extant literature concerning asset, service provision and associated natural capital benefits were reviewed to inform a basic approach and identify major gaps in understanding. Where resource allowed, significant gaps were addressed through approaches that met the assumptions of the Pioneer (Box 1)**.** Those are highlighted in yellow in Figure 6.
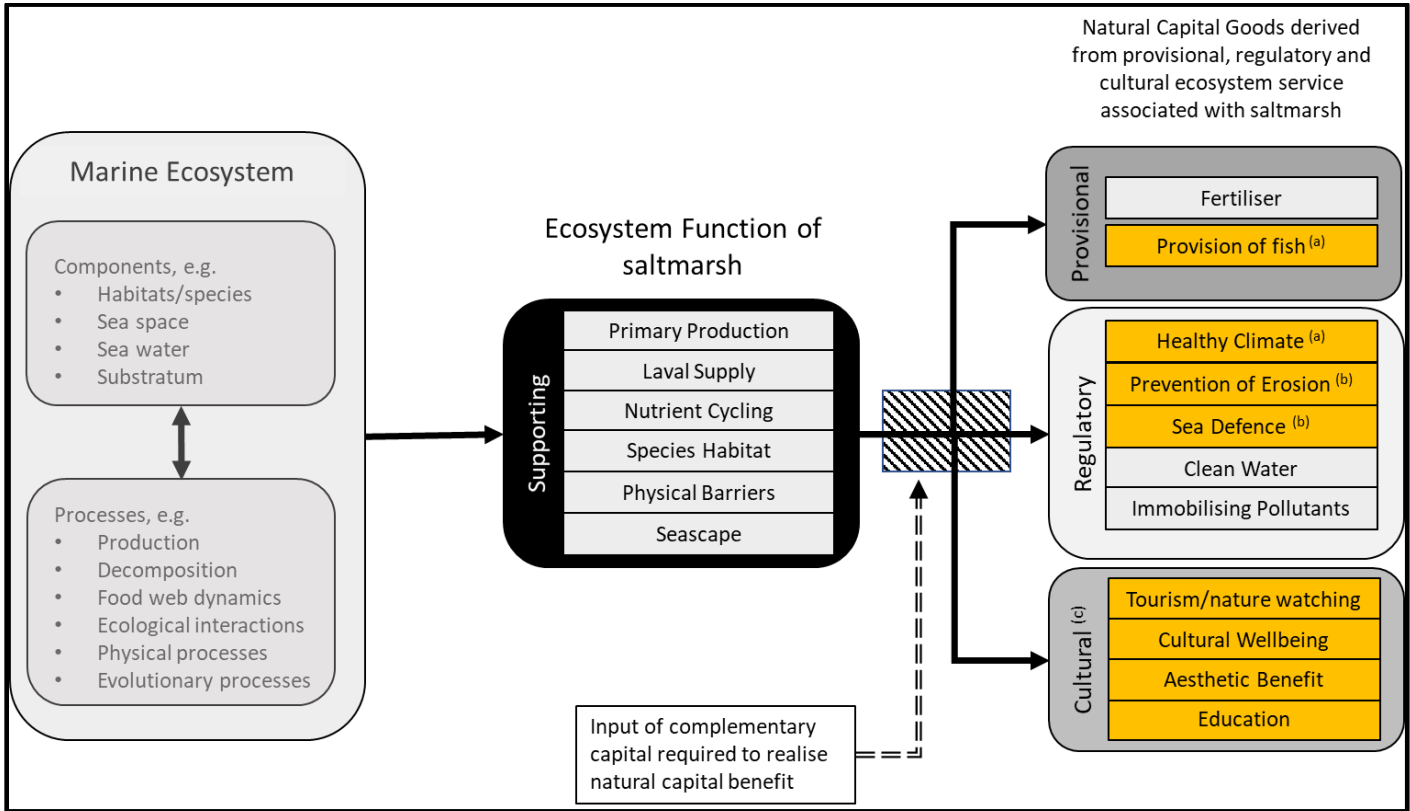
Figure 6: Representation of the ecosystem services and appreciable benefits (natural capital goods) of salt marsh edited from Potts et al., (2014) and informed by Natural England (2012). From left to right, generic components and processes of the marine ecosystem are shown. The ecosystem underpins the ecosystem functioning, specific to salt marsh (supporting ecosystem services). The ecosystem function delivers a range of goods that benefit human wellbeing through provisional, regulatory or cultural ecosystem services. Yellow highlighting indicates benefits the Pioneer targeted to gain a better understanding of how these natural capital goods manifest for the salt marsh of the Suffolk estuaries. The notations, [a], [b] and [c] reference full technical reports commissioned by the Pioneer. These are: [a]Slee et al., 2018, [b] Rogers & Möller (2019) and [c] Grilli et al., (unpublished).

Ecosystem service provision

The Pioneer developed methods that interrogated physical data to inform an understanding of goods derived from regulatory and provisional ecosystem services (See boxes four, five and six of the technical annex). Cultural ecosystem services cannot be quantified in the same way however because the relationship between biophysical and cultural service delivery is relatively weak (Gliozzo et al., 2016), with service delivery subjectively determined by the beneficiaries. The delivery of benefit can however be approximated by evaluating peoples' choices and interactions with natural assets (Sunderland et al., 2018). Multiple methodologies could be used to this elicit data, as inferred in the NCC framework.

The Pioneer chose to examine cultural ecosystem services by way of a willingness to pay study of Deben estuary salt marsh. This work is summarised in the Box 7 of the technical annex (Grilli et al., unpublished). Some authors have proposed that quantifying service provision and value for cultural services should focus more on change in service delivery rather than absolute service delivery (Small et al., 2017) this will be considered when influencing decision makers.

Valuing Natural Capital

Obtaining valuations for natural capital is critical to the success of the approach as the act of valuation can convert the multiple units required to convey quantity or service provision into a single, fungible unit. Currency is universally understood and heralded by economists as the objective for natural capital thinking. The Office for National Statistics (ONS) are iterating a natural capital accounting methodology that is intended to apply to the 25YEP. To date, the ONS have produced a series of accounts for English and Scottish habitat types[20] and most recently a UK natural capital account. To ensure consistency with national accounting the Pioneer drew on this methodology when attempting to define value of salt marsh ecosystem service provision (Holt, 2018). Box 8 of the technical annex provides more detail.

Evidence Review

Building on the evidence base is intended to inform a series of potential natural capital plans that are inclusive of: inputs, outcomes and beneficiaries. The evidence base only becomes informative when the information supporting it is organised into asset and risk registers alongside natural capital accounts. Table 4 summarises the Pioneer's evidence base and effectively amalgamates the asset register with the natural capital account. It is acknowledged that this asset register is incomplete.

Table 4: An asset register for Suffolk salt marsh, complied from the outputs of the evidence base complied by the Suffolk Marine Pioneer, as summarised in Boxes 4 through 7.

Asset: Deben estuarine salt marsh (UK East Coast estuarine marsh)			
Asset Condition: Varied across estuary. Slee et al., (2018) Pilot identifies a condition of extant marsh ranges between 30%-80% full health			
Asset Extent: Deben Estuary = 234.43 (ha) as of 2007.			
Natural Capital Benefits*	**Service provision***	**Beneficiaries***	**Value***
Fertiliser	TBC	TBC	TBC
Provision of fish	78 fish (1 year +) per tide per hectare of salt marsh (assuming 88% marsh 12% creek).	n/a	£11.76 ha-1
Healthy climate (CO₂ storage)	3684 g C m2, (SE ± 152) for vegetated 1647 g C m2, (SE± 42.9) for unvegetated	n/a	£4969-£8455 ha-1(2019)
Healthy climate (CO₂ sequestration)	2.85 t CO^2 ha-1 yr-1 (Burdon et al., 2019)	n/a	£67 ha-1 (2019)
Prevention of erosion	Location specific - As per Möller (2019)	n/a	n/a
Sea defence	Location specific - As per Möller (2019)	n/a	n/a
Clean water	TBC	TBC	TBC
Immobilising pollutants	TBC	TBC	TBC
Tourism	Not quantified or but assessed in terms of change of service.	Circa £4 per household/year for large-scale restoration projects with access to saltmarsh[21]	
Cultural wellbeing			
Aesthetic benefit			
Education			
Sum Total			

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[20] https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalaccounts/2019
[21] Preliminary results based on Grilli et al (unpublished)

Slee et al., (2018) and Holt (2019) informed the provision of fish and the carbon benefits of salt marsh. This is detailed in Table 4 in the original units as well as in financial terms. The work of Rogers and Möller (2019) quantified the benefit of coastal defence and prevention of erosion, expressed in terms of reduced wave height. The values derived from Rogers and Möller cannot however be meaningfully summarised into a single, translatable figure because the outputs of this work are only meaningfully applied spatially. The Rogers and Möller (2019) work is perhaps the most informative for decision makers as it relates benefit to place, and by extension to people[22]. It is in this instance that the desire to financially account for the natural environment becomes exposed in attempting to oversimplify natural systems and so a case is made for embracing complexity to match the desire for better decision making.

Should natural capital implementation require information to be presented within accounts, information not meeting this requirement might be excluded and decisions made in ignorance of it. An appropriate decision may be made where information is knowingly excluded but the process will not be informed by the best available evidence.

Understanding the consequence of decisions informed by natural capital evidence is critical to determine the effectiveness of a natural capital approach. If the sustainability of decision making is not improved where informed by natural capital arguments, the conclusion must be drawn that the approach has failed in such instances. It is recommended that implementation be monitored to determine minimum standards and requirements for evidence.

A significant weakness of the Pioneer's evidence base is the inability to effectively and consistently relate provision of ecosystem service to the beneficiaries of the service[23]. Despite this, monetary valuations were attained for several services of salt marsh. The ability to generate monetary values for services despite data deficiencies poses questions from an implementation perspective as presenting figures implies a comprehensive value to the end user. Studies have shown that presenting natural capital accounts for decision makers may have a detrimental impact on the state of the natural environment because the assumption is made that the values are fully accountable (Temel et al., 2018). The presence of such risk makes for an argument that natural capital should not be viewed exclusively through an economic lens, rather as a holistic framing tool where multiple valuing perspectives can be considered from a systems perspective. Regardless of how natural capital is framed, a mechanism that helps standardise reporting formatting, to promote user recognition of incomplete evidence is recommended.

Academically, it is useful to visualise the relative incompleteness of the evidence base. Figure 7 subjectively illustrates this against a comprehensive understanding for each benefit.

The observed variance in Figure 7 might reasonably be justified by the quantity of resource assigned to each task. Making this assumption may however act to conceal the complexity of evidence collection. The experience of the Pioneer is that progress made in quantifying the relationship between natural assets and realised goods & services is a function of our understanding of the relationships between asset, service and social reality (Figure 4). The reality being some natural capital benefits are harder to define than others.

The North Devon Marine Pioneer demonstrated a pathway to developing asset and risk registers at an ecosystem scale for the North Devon Biosphere (Rees et al. 2018). Despite being relatively well funded, the Rees et al. asset register exhibited similar information gaps to the Pioneer.

If developing a timely and comprehensive evidence base is impractical or too expensive, it is necessary to consider the consequences of implementing the natural capital approach without it. If the Pioneer's experience is representative of the natural capital approach based on the assumption that projects operate on finite resource and timescales, it is reasonable to assume that decision makers will be exposed to inaccurate summarises of natural capital value thereby risking the integrity of assets and undermining the natural capital approach. The effect of undervaluing

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[22] Acknowledging that beneficiaries have not been defined.
[23] See Stage 5, Implementation for additional comment.

the environment has been demonstrated by the continued degradation of natural assets over the past 70 years (WWF, 2018).
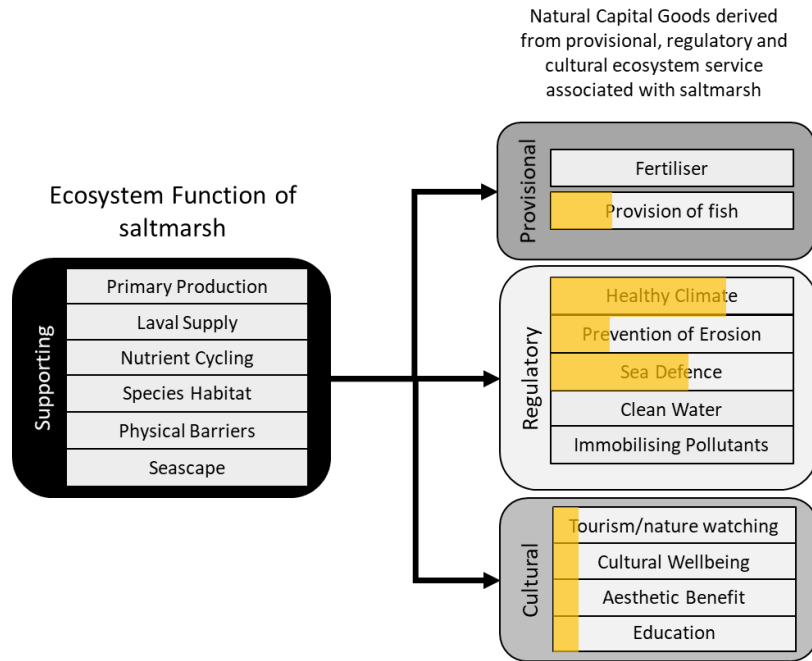

Figure 7: Compressed schematic of the ecosystem services and benefits associated with salt marsh. Yellow shading is a subjective representation of how developed the Pioneer's evidence base is relative to a comprehensive evidence base.

Environmental science has always sought to influence decision making through evidence-led debate. The cost and limitations associated with developing a natural capital evidence base, based on the Pioneer's experience, indicates evidence is insufficient to instil confidence in decision making and so should not be considered a 'silver bullet'.

It may be possible to supplement natural capital by exploring multi-disciplinary approaches. For example, social and computer sciences may hold promise for natural capital managers who require high intensity data analysis. Citizen science may offer value in wider context, as might structured participatory approaches, especially for defining beneficiaries[24].

Key Learning: Building an evidence base

Many of the lessons learnt by the Pioneer when developing a natural capital evidence base only became apparent at or after the point where options (Stage 4) were considered. Such lessons are considered here because this is the stage where resource is committed to deliver the evidence.

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[24] Annex 1.
* The Natural Capital Committee's phrasing of 'Potential plans' risks confusion in this context because it refers to opportunities for specific assets or geographies rather than a collective of everything a natural capital plan would cover. This document refers to these opportunities as 'possible interventions' and only refers to 'plan' in the context of the product of a complete natural capital plan.

Change

- Defining the beneficiaries of natural capital is considered one of the most challenging but important aspects of building an evidence base. Participatory approaches can draw upon different value perspectives to support deficiencies in monetary valuations and promote a holistic view of natural capital.
- Evidence to support the identification and relative responsibilities of beneficiaries, relative to natural capital assets appears critical to the success of the natural capital approach. The Pioneer advocates that it would be unwise to progress beyond evidence collection without this information.
- Data collected for purposes other than informing natural capital planning (WFD, MSFD, Habitats and Birds directives etc) is highly unlikely to inform natural capital planning without additional analysis. This finding is challenges the assertion of the [25 YEP draft indicators for monitoring](#), published by Defra (2020).
- The complexity of the natural capital approach should be embraced. This is illustrated well by an inability to simplify the work of Rogers and Möller (2019) to fit into a basic accounting format.

Governance

- An evidence base is required to serve two objectives:
  - To inform natural capital plan development
  - Evidence valuations of assets to inform natural capital accounting and so influence *better* decision making
- The success of the natural capital approach is based on the ability of an empirical evidence base to influence decision making. This route to successful implementation of the natural capital approach should not be assumed as decisions are often influenced by external, sometimes irrational factors that may wield greater influence than evidence.
- The scale of decisions affected by a natural capital plan and at which assets are considered, for example intervention, should be agreed proactively as this information will inform data requirements to understand service provision.
- Understanding the governance of the natural capital planning process, notably on when and how decisions are made in developing a natural capital plan may influence the way in which evidence is collected.
- No best practice guidance on natural capital governance exists, but it is critical to distinguish between autocractic approaches and planning in partnership. Doing so informs how circuitous the decision-making during plan development and/or implementation is likely to be. It therefore identifies the relative need for the components of the evidence base to be both comprehensible and trusted.
- Design of asset, risk register is not generic but should be developed to meet user needs. Understanding who the users of the asset and risk register are, is likely to come when establishing plan governance. It is acknowledged neither the asset nor risk registers necessarily need to be comprehensive before they may inform decision making but that a lack of information regarding beneficiaries is likely to increase the risks associated with planning and implementation.
- Acknowledging the requirement to meet specific user needs, a universal reporting framework is recommended to ensure a common approach to identify data deficiencies in evidence base that can instantly be recognised by different user groups.
- Developing a comprehensive natural capital evidence base is difficult but it is assumed that natural capital plans will progress to implementation with some data deficiencies. Understanding the stakeholders, governance structures and route to impact are expected to support progress, but not substitute for unavailable data.

Methods

- The Pioneer has demonstrated a series of methods that can interrogate public data to quantify ecosystem service provision at high resolution (<10m) These methods (Slee et al, 2018 Möller & Rogers 2019) could be provide opportunity to monitor key indicators (service provision) without significant additional cost.
- A literature scoping the assets and services pertinent to the vision will help direct resourcing for the evidence base. Dependent on confidence requirements, the literature may in some cases, negate the need for additional data collection.
- An understanding of how ecosystem services manifest is fundamental to informing what evidence is necessary to acquire. Gaining this understanding will help determine what the constituents of good/bad condition are for the assets in question.
- A natural capital evidence base may be developed sequentially, starting from either the supply (assets) or demand (benefits) side. Beginning from a demand perspective poses a relatively greater risk to environmental improvement objectives because design and progress of evidence collection are more likely influenced by social and political influences beyond life and physical sciences.
- An inherent trade-off exists between evidence comprehensibility and coverage when it is intended to influence policy. Partnership approaches to natural capital planning are likely to require more robust evidence bases to ensure communication of change, intervention, ecosystem service and benefit is comprehensible and instils trust.
- Developing evidence requires multiple methodologies and examination of this information will mandate GIS software.

Funding

- If natural capital is to inform locally relevant decision making (be it private, public or partnership) the viability of ONS accounting methods should be questioned because these do not account for beneficiaries specific to the assets such that they do not offer confidence to those making decision.

Stage 4: Identify Your Options

Theory

Stage four is intended to assess the options available to deliver the vision in terms of: action; intervention; and investment. To agree a preferred option will be the expected output of this stage. Theoretically the preferred option should be objectively directed by the evidence base. Where natural capital planning is developed in partnership, a consensus on the preferred option is required. This may be achieved through several mechanisms including: scenario development, modelling and deliberative discussion.

Context

The Pioneer had a local focus when addressing the natural capital approach. The options process therefore considered specific interventions rather than strategic options for delivery. Broader planning processes or those considering large geographic areas are likely to require more strategic options.

Environmental economists cite currency (typically $) as the best metric to express the value of natural capital. However, beneficiaries often use diverse and varied metrics to express value – a fact that complicates economic valuation of cultural ecosystem services. The Pioneer's evidence base lacked the necessary comprehension to inform a fully representative monetary valuation for Deben salt marsh (Table 4). Faced with an information deficit that removed the ability to make an outright objective decision regarding options, the Pioneer sought to inform the options process by obtaining an understanding of other value metrics.

The weaknesses of the Pioneer's evidence base dictated the options process could not be entirely evidence led. In lieu of this, defining which interventions are most suited to deliver the vision requires subjective analysis. This carried with it the inherent risk of under valuing the natural environment because the natural capital evidence is not robust enough to circumvent it.

Experience & Outputs

The Pioneer commissioned the Institute for Estuarine & Coastal Studies (IECS) at the University of Hull and the University Aberdeen to conduct an inclusive participatory exercise to elicit a wider understanding of value for the Deben estuary. Though not a specific objective of this work, the Pioneer anticipated that this approach would act to supplement the evidence base with perceived values beyond monetary. This broader span of information was hoped to facilitate delivery of a formal options process.

Monetary values are heralded as the gold standard for natural capital approaches as they permit equitable comparison across multiple parameters and are readily communicable. Natural capital approaches that consider multiple value perspectives, i.e., currency and aesthetic appreciation, may find 'value' becomes harder to define, and so are less informative for decision makers. Lacking the comprehensive evidence necessary to lead the options decision, the Pioneer had to trade-off between the depth of the evidence base communicated to those involved in decision making and the decision makers' ability to compute the data. This trade off was managed in part by the participatory approach through:

- Building a common understanding of ecosystem services, natural capital and the aspiration to improve the state of the environment for all participants (Burdon, 2019 a,b)
- Establishing a common asset map of the Deben Estuary by requesting participants to identify natural assets and relate these assets to perceived benefits (Burdon, 2019 a,b).

A majority of participants formed an understanding of ecosystem services and could equate benefits from these services to features within a familiar geography. The ability to distinguish natural assets from those modified or managed by people, for example: farmland, golf course, reservoir, influenced discussion. This was notable in that it

supported an anthropocentric view of natural capital. Participants ability to associate features with benefits was correlated with their experience and scientific understanding.

Participants were requested to consolidate views into a final, agreed benefit map (Figure 8). This was assisted by the presentation of a national assessment relating benefit to natural features (Potts et al., 2014). It became apparent that the national assessment did not automatically translate to a local place-based approach as participants challenged the theoretical delivery of services and benefits based on their experience. This is indicative of the nuances of place-based decision making highlighting the inadequacy of large-scale reviews to capture these relationships and supporting the application of participatory approaches.
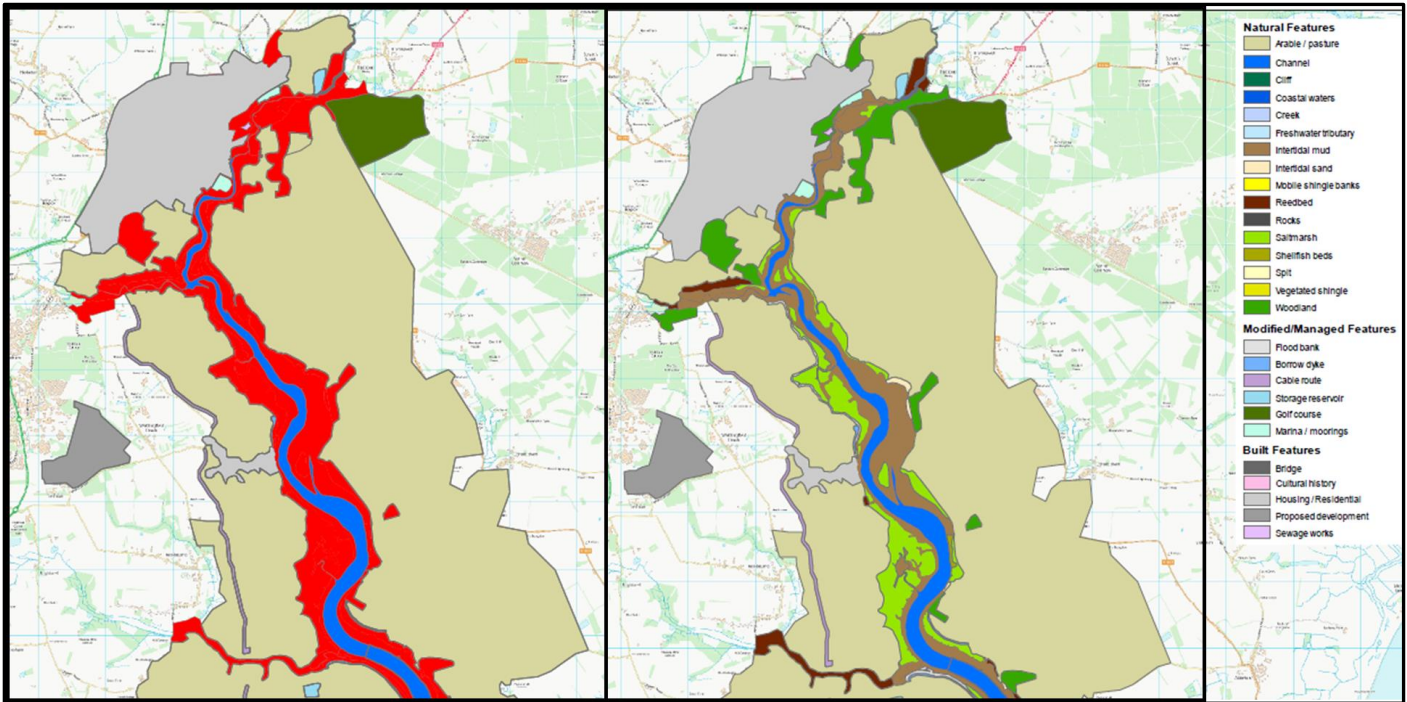

Figure 8: Natural capital assets and benefits map produced as a part of the participatory approach to natural capital options process under the Marine Pioneer (Burdon et al., 2019b). Assets (right) were identified by participants and grouped under NEA classifications. Benefits, (left shown for Natural hazard regulation by red shading) were defined through association of participants with notable assets.

The need to better understand the relative importance of natural features required further examination. To explore trade-offs the project team created two hypothetical scenarios to assess benefit delivery: 1) A realignment of estuary banks resulting in loss of farmland and gain in salt marsh formed one scenario, and; 2) Predicted sea level rise reduced the level of vegetated marsh, transforming the intertidal environment from vegetated marsh to unvegetated mudflats (Burdon et al., 2019c). Participants were asked to score the perceived change in benefits under each scenario. Results of this are shown in Figure 8 with full report provided in the technical annex.

Figure 9 demonstrates participants were able to understand relationships between asset and benefit. It appeared however, that individual perspective influenced thoughts on the relative importance of these relationships. Language barriers and a desire of participants to understand the implications of changes were recorded as potential explanations for this. Participants rejected the value of hypothetical discussion to consider values and priorities, in favour of greater specific place-based scenarios that were supported by information on implication and costing.

The generation of public good was not viewed positively where the precise nature of the good was not attributable to specific stakeholders. This perception was heightened where generation of public good came at the expense of direct

losses to an individual. Landowners, for example. This reaction supports the need to identify specific beneficiaries and incorporate these into natural capital decision making and processes.

Undertaking this exercise revealed several important lessons regarding community engagement with natural capital.
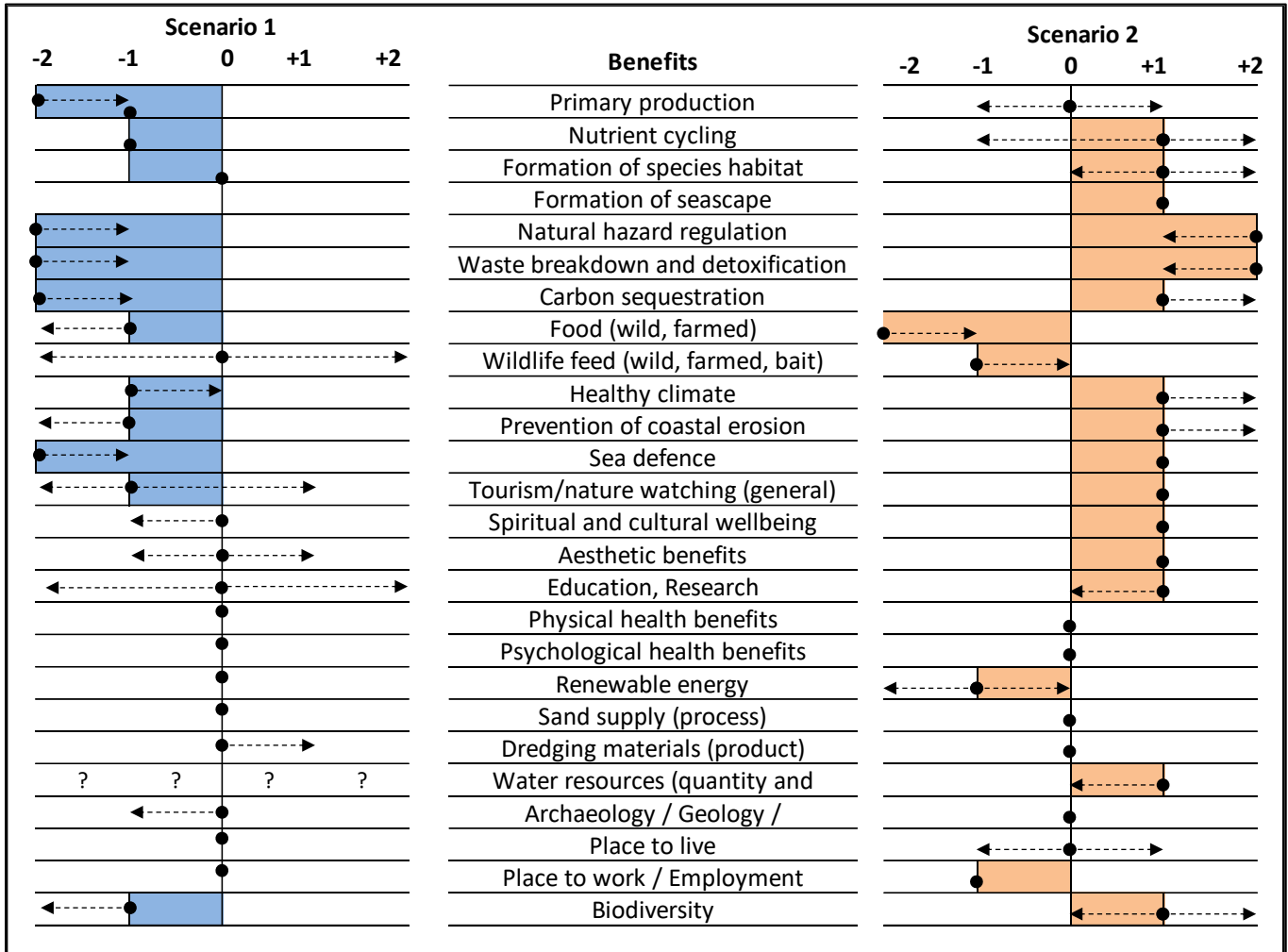
Figure 9: Deben estuary stakeholder perceptions of net change in benefits derived from natural assets induced by hypothetical managed realignment (Scenario 1) and salt marsh degradation (Scenario 2) relative to business as usual (no change) (adapted from Burdon et al., 2019c). Participants (n=19) were asked to score on a Likert scale where: -2 = large decrease of benefit, -1 = small decrease, 0 = stay the same, +1 = small increase, +2 = large increase, ? = unknown. Arrows indicate variation on opinion across three groups, where larger ranges indicate less consensus.

Key Learning: Identifying your Options

Change

- For place-based planning, it is unlikely that a natural capital evidence base alone will reliably inform the options process. To support this, some form of participatory process is advocated.
- A participatory approach enables the stakeholders to debate in the same language and is an essential step in informing the process. This can be facilitated for specific cases or for hypothetical scenarios. With regard to natural capital planning, greater specificity of scenario is expected to support decision making.

Governance

- Critical to any participatory or consultation event is the need to engage a full spectrum of stakeholders.

Method

- Applying the language of ecosystem services and natural capital remains problematic even in cases where a baseline understanding is developed. Participatory approaches can help address this by allowing stakeholders to address natural capital concepts in their own terms.

- Disbenefits should be included alongside benefits in all discussion. This is particularly pressing for assessing disparate scenarios for example, land versus sea, where benefits will not always align.

- Understanding the implications of a scenario for people is important for local participatory approaches. To do this requires an understanding of the population, its demographic, distribution and their relationships & dependencies on natural assets.

Funding

- Stakeholders require expected economic change induced by natural capital intervention to be quantified. It is also noted that the costs of instigating change and the expected timescale of benefit availability are demanded. For example, the costs to physically change arable land into salt marsh

- The importance of understanding indirect benefits and disbenefits was raised for local and rural communities where small changes have led to impacts across a broad spectrum of people due to the interconnectivity throughout close communities. This includes supply chains and local markets effects.

Stage 5: Implementation

Theory

The NCC framework states that the successful implementation of a natural capital plan should set out the goals, measures, milestones and actions together with the relevant accountabilities and responsibilities. It acknowledges that delivery requires integrated working across multiple partners and a pooling of resource.

Where partners are unfamiliar with aligning objectives in partnership there is a real risk of pathways to delivery being disputed. This risk is heightened for natural capital approaches informed by limited evidence, particularly where responsibility and beneficiaries are debated. It is critical that there is a clear governance structure in place prior to implementation together with a plan to finance the work.

As a natural capital plan is implemented there needs to be an effective process for monitoring and evaluation to enable effective revision as it is required. The outcomes from the monitoring and evaluation should be fed back to natural capital managers overseeing the plan so they can vary inputs and subsequent outcomes as appropriate.

Context

The publication of a plan, natural capital or otherwise, does not change how relevant decisions are made. It is necessary to ensure that partner support and governance structures are in place prior to implementation to enable the plan to take effect. Guidance to inform natural capital plan implementation is evolving (Enabling a Natural Capital Approach) so early adopters of the natural capital approach will likely need to adapt through trial and error.

The Pioneer was unable to conduct a sufficiently refined options process to identify intervention opportunities and plan these out strategically. The participatory approach to options did however identify potential hurdles to successful implementation, namely an understanding of consequence and responsibility.

In developing the evidence base, the Pioneer attempted to identify beneficiaries (and so infer responsibility for natural assets) by tracking the delivery of natural capital benefits from the ecosystem to the human population. This approach implies a geographic link, that those closer to an asset are more likely to benefit from it. Willingness to pay studies appear to confirm this as the amounts respondents are prepared to pay is often inversely correlated with distance from the study site. Such a correlation masks the complexity of practical implementation of such a system. These challenges are not considered here however a key factor in the Pioneer's decision not to progress this line of enquiry was the environmentally perverse logic of this approach. Notably natural assets in areas of dense population are deemed to be of higher value than those in remote areas. Though this has some logic – a public green space in the centre of a city offers greater value than a similar greenspace where no one resides, it would fail to recognise the high value of rich and endemic biodiversity on a deserted island, thus risks the intent of the 25YEP.

Following the outputs of the participatory workshops, the Pioneer sought to define natural capital beneficiaries from a users' perspective. This approach has previously been acknowledged to pose a risk to environmental improvement, as users won't recognise all of the benefits they derive from the environment. To succeed, a mechanism would be required to mitigate this by devising logic chains that empirically demonstrate links from assets, through ecosystem service delivery and natural capital benefits to user requirements. It would then need to communicate this information in a succinct and appealing format.

Burdon et al (2020) developed a methodology by which the practicalities of such logic chains could be tested by building on the participatory process undertaken by the Pioneer. A mechanism to define beneficiaries by their 'reliance' on natural capital was proposed. This would allow organisations to identify common interests and reliance, facilitate collaboration for mutual benefit, in terms of asset management and business continuity and helped identify

relative importance of service provision within a given geography. The outputs are presented graphically as radar plots against defined ecosystem services and natural capital benefits (Figure 10).
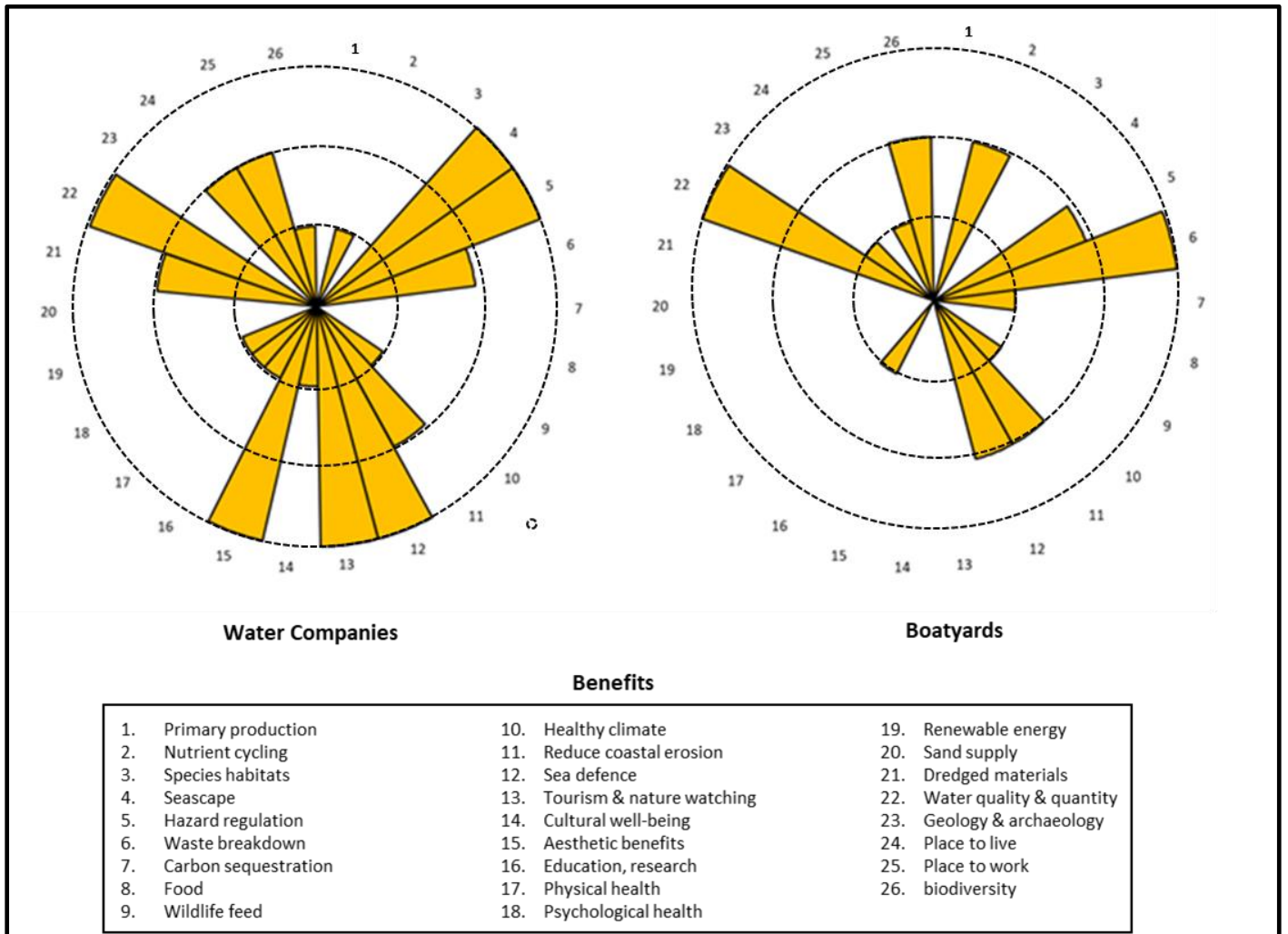

Figure 10: Graphical representation of organisational reliance on natural capital benefits, as defined through participatory process. Radar plots illustrate relate importance of relationship by length of bars (0 [no bar], 1,2 and 3). These outputs are illustrative of the concept and should not be considered definitive as the definition of 'reliance', 'importance' and 'benefit' was not agreed.

To inform effective decision making, work is now required to relate benefits back to natural assets. This can easily be achieved by reviewing literature. The approach of Natural England (2012) developed further by Potts et al (2014) and Burdon et al. (2017) provides an excellent source to inform this.

Where natural capital asset registers exist, it may be possible to compare aggregated requirement plots against existing asset extent (Figure 11). This would effectively provide information on supply and demand, allowing natural capital managers to make a reasoned case for interventions to support particular assets and services. The value (and willingness to pay) would be determined by those organisations dependent on the benefits expected by the proposed interventions.
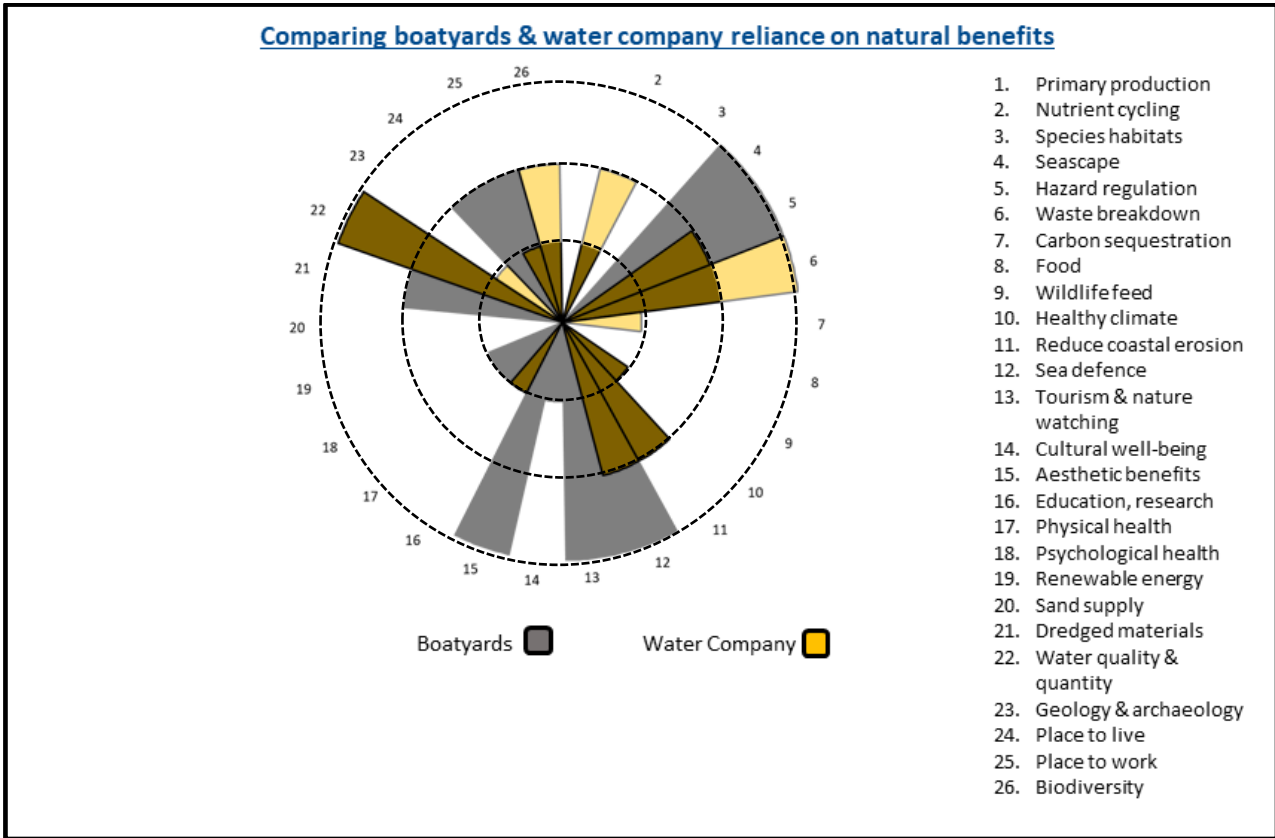
Figure 11: Illustrative comparative analysis of organisational reliance on natural capital benefits. Radar plots of reliance on natural benefits has been overlaid for water companies and boatyards. Relative importance is indicated by the size of plot for each benefit (0,1,2,3). Where organisations identify the same level of reliance for example benefits 10 and 11, or key differences. For example, benefit 15 where boatyard =3 and water company = 0. This information may be useful to inform mutually benefit cross-sector planning.

Experience & Outputs

As a consequence of increased awareness of the natural capital approach and greater knowledge of its application in government policy, several outlets have commenced planning processes informed by natural capital. Notably a consortium of public authorities including New Anglia Local Enterprise Partnership, Suffolk County Council and Norfolk County Council have ambition to produce a joint, regional environment strategy that spans terrestrial and marine to compliment regional economic planning and mimic national approach. Additionally, the Deben Estuary Partnership is seeking to review the existing document to reflect a natural capital approach. These actions in East Anglia are mirrored by similar activity across the country, from the North Devon Marine Natural Capital Plan and the OxCam Arc.

Key Learning: Implementation

Learning from implementing a natural capital approach is continual. Both plan development processes in East Anglia are in the early stages, still seeking to define their respective baselines. The progress of the regional environment plan has informed several lessons reported across this document, particularly in terms of partnership group reactions to evidence, beneficiaries and governance.

Discussion

The Suffolk Marine Pioneer project was required to test a natural capital approach at a local level. To achieve this, the Pioneer concerned itself with a single natural capital asset – salt marsh. This decision was informed by data availability, community interest, accessibility and with input from project partners. The consequence of this decision was that the Pioneer was able to examine the five stages of the natural capital approach, as defined by the Natural Capital Committee, in such a way that generated outputs with clear application to natural capital managers seeking to deliver a local approach. The lessons and outputs of the Suffolk Marine Pioneer are intended to informative for all parties considering taking a natural capital approach, regardless of environment or location of consideration. It is likely that the effectiveness of the Pioneer's lessons and recommendations will be impacted by future government guidance on the subject. To assess the likely significance of this and other external drivers on the lessons and recommendations, the reader is directed to review the assumptions, in Box 1.

The ambition of the 25 Year Environment Plan, coupled with the continued, documented degradation of the natural environment demonstrates a necessity to adapt current practices if natural capital is to improve the state of the environment. If lessons are not heeded and natural capital decision making is not properly considered in advance of implementation, the experience of the Pioneer suggests the natural capital approach could fail to deliver. This risk of failure, relative to the ambitions of the 25 Year Environment Plan, is not restricted to one avenue. Indeed, the potential for natural capital approaches to fail stem from many multiple directions. It is the recommendation of the Pioneer that the natural capital approach and it's intent, be reviewed and the routes to effective delivery be evaluated from a national perspective before the natural capital approach is adopted widely. Such an evaluation should look to inform a more focussed intent on natural capital application.

The Pioneer has reported lessons and recommendations across four themes; Change, Governance, Methods and Funding for every stage of the process.

A significant requirement of change is the need to work collaboratively across organisations towards shared goals. Forming new, potential complex working partnerships necessitate that strong and proactive governance structures are in place and are suitably robust to identify and direct action of multiple parties acting in a dynamic environment.

The requirement to manage and interpret multiple datasets has long been acknowledged as a cornerstone of the natural capital approach. The Pioneer has learned that existing data often require technical manipulation before they can usefully inform a local natural capital approach. In addressing this issue for the salt marsh, the Pioneer developed a number of methodologies that could be applied nationally at minimal expense. The Pioneer acknowledges that communication of the evidence is critical to success and that natural capital planning should integrate across boundaries as so far as possible. This drive raises expectation of a default or preferred approach to developing evidence, as minimising variation in methodology supports data integration. However, the Pioneer acknowledges a requirement to produce situation specific natural capital data to bridge barriers to implementation locally. This need may conflict with that for integration at scale.

Both individually and in combination, the outputs of the Pioneer have been highly successful. However, the requirement to build an evidence base to inform natural capital decision making is time consuming and does not currently fit into the demands of everyday decision making. It is expected that the uptake of these tools, and that of others outside the scope of the Pioneer is likely to be closely linked to the simplicity of combining them. The Pioneer experienced issues in doing this for even a small geography. The Government's recently published *Enabling a Natural Capital Approach Guidance* makes a useful step towards steering parties towards tools, but the Pioneer expects decision makers will require greater prescription of tools and processes to truly embrace natural capital thinking.

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Technical Annex

BOX 3: Defining Extent and Condition (Slee at al 2018)	
University of Essex	
Requirements	To accurately define the extent of salt marsh from spatially disaggregated public data that offers national coverage. Condition is harder to define than extent because what defines 'condition' is dependent on one's expectation of delivery. For example, vegetation composition and the physical features of the marsh, including vegetative structure influence service provision, such that a salt marsh may yield certain services and benefits in one state to the detriment of other services and benefits[25]. As such, a generic condition assessment was sought, one defined by a state of maturity (ecological equilibrium). Healthy, established salt marsh is known to be composed of 88% vegetated marsh and 12%± 1.95 % creeks (Green et al., 2009, 2012). An assessment of condition therefore required data on creek density, vegetation structure and vegetation composition.
Available Information	As previously noted, Natural England's Priority Habitat Inventory provides a UK wide, spatial dataset that describes the geographic extent of habitats of principal importance, including salt marsh, as listed in Section 41 of the Natural Environment and Rural Communities Act (2006). More specifically, salt marsh extent is freely available as polygon data for all coastal and transitional waterbodies in England. Extent is defined from aerial imagery to a resolution of $100cm^2$ and the 2014 data are publicly available via Open Government licence https://environment.data.gov.uk/. Aerial (Environment Agency et al) and satellite (Sentinel II) photographic data is available for all of the country to a certain degree of resolution. Open access LIDAR data provided by the Environment Agency is updated bi-annually to account for new surveys. Coverage extends to <60% of England at 1m resolution, though survey data exists for a proportion of this area of up to 25cm. Natural England assessment of SSSIs through National Vegetation Classification assessments can reliably inform vegetation type and extent. However as for many NVC datasets, the relevant surveys (Abrehart, 2013) are not spatially disaggregated and are only available as written reports which limits their value to reasonably assess condition.
Identified Gaps	Condition is indeterminable from available data without further analysis.

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[25] This raises the question of who benefits, and affirms the issues progressing a natural capital evidence base from the perspective of the beneficiaries.

Solution	Define condition of salt marsh through analysing morphology including; creek density and vegetation coverage against healthy standards (Green et al., 2009, 2012). Demonstrate transferable methods through conducting a pilot study for selected Deben marshes.
Method Summary	- Determine extent of marsh of interest by interrogating Priority Habitat Inventory Shape files (Natural England Open Data) - Determine percentage vegetation cover through undertaking an image analysis of aerial photograph using opensource freeware e.g. ImageJ (Environment Agency Open Data). Method is developed from Green et al. (2009). - Define relative condition by assessing percentage vegetation coverage against known value for healthy salt marsh in East Anglia (Green et al. 2012). Analysis of pilot site indicated that salt marsh on the Deben was in poorer condition than the defined healthy standard (88% vegetation cover), this supports the conclusions of the SSSI site assessment findings. These data may be processed to yield a more informative metric than SSSI site condition assessments, if deviation from the standard of Green et al is considered and expressed in percentage terms. The data reveal the relative health of discrete marshes, ranging from 30% (Loder's Cut) to 80% (Melton marsh) health.
Applications	The method establishes extent and condition by analysing physical morphology of salt marsh. The method can be applied at various scales that can usefully inform intra asset prioritisation which is particularly useful at a local or regional scale where the precise location of intervention is important. Condition was defined relative to the theoretical optimum conditions for this floristic type of marsh. This method may be extrapolated for other salt marshes that are in clay-rich habitat, notably across East Anglia, Kent and across the North Sea. Outside of these regions, 'healthy' may need to be redefined through specific tests or may already be defined elsewhere in literature. Where managers seek to apply a natural capital approach at an ecosystem scale, it may be feasible to present condition assessment as a percentage, so as to define a relative condition status for particular assets. Where this information is combined with trend analysis, this could usefully inform prioritisation for intervention on asset types and act as indicator for asset monitoring, perhaps valuable for protected areas. The validity of such assessment could usefully be tested against SSSI assessments, where determination is categorised (Favourable; Unfavourable recovering; Unfavourable no change; Unfavourable declining; Part destroyed; Destroyed) It should be noted that the successful application of this method (adapted or otherwise) to other assets was not considered by Slee et al. If it can be suitably adjusted, it has the potential to inform inter-asset prioritisation. It is acknowledged that national vegetation classification survey data are available and highly informative. It is recommended that these are spatially disaggregated to enable these data to inform condition assessment for multiple habitats.

Box 3 outlines an understanding of asset condition. Following the logic set out by Figure 4, the next priority should be the consideration of ecosystem service provision.

Reviewing the literature, the Millennium Ecosystem Assessment (MEA) offers insight into generic ecosystem service relationships. This is developed more specifically for the UK through the National Ecosystem Assessment (2012) but remains relatively distant from the specifics of Suffolk salt marsh.

A discrepancy between theoretical and empirical service provision of specific assets is expected. This discrepancy risks the success of delivering environmental improvement as inaccuracies estimating service provision compound through defining values and in decision making. The Pioneer sought to derive reliable estimates of service provision by relating benefits to specific ecosystem service for a defined asset, as per Slee et al., (2018). Boxes 4 through 7 summarise the evidence for this.

Box 4: Defining Service Provision - Healthy Climate (Slee et al., 2018)	
University of Essex	
Requirements	To quantify the specific carbon storage and sequestration service and potential for Deben estuary salt marsh sufficient to instil investor confidence in a proposed 'Suffolk Salt marsh fund'.
Available Information	The carbon cycle is understood and has been quantified for various marsh types. • Carbon sequestration of salt marsh is understood to be 210 g C m^3 yr (Chmura et al., 2003). • Carbon storage for salt marsh and mudflat is also known for East coast marshes. Mud flats store 1647 g C m2, (SE± 42.9) in the top 10cm and salt marshes 3684 g C m2, (SE ± 152) (Thornton et al., 2002). • Rates of carbon sequestration in East of England marshes are known. Carbon accumulation is initially rapid (average 1.04 t C ha−1 yr−1 during the first 20 years), slowing to a steady rate of around 0.65 t C ha−1 yr−1 thereafter. Restored marshes deliver carbon stock benefits within 100 years (Burden et al., 2019).
Identified Gaps	It is acknowledged that salt marsh sequesters and stores carbon, but that the extent to which this occurs can vary for numerous reasons (Alonso et al., 2012). It was not known where in the range of possible value, the marsh of the Deben lies. Refining estimates of service provision was considered critical to provide investor confidence in a proposed Salt marsh Carbon Credit scheme, considered by Suffolk Coast Forum members. Salt marsh restoration has been identified as a plausible natural capital intervention for the Suffolk Marine Pioneer. Understanding the potential to derive benefit from intervention could usefully inform decision making as regards to which marshes are targeted for intervention.
Solutions	The University of Essex (Slee et al., 2018) were able to combine extent and condition analysis (discussed in Box 3) with generic data on marsh storage potential and sequestration rates to demonstrate service provision of Deben salt marsh and to extrapolate change in service provision under plausible gain/ loss scenarios. Value, monetary or otherwise was not considered in this work. Valuation is considered in Box 8.

Method Summary	Specific locations of marsh on the Deben estuary were used. Selected marshes were intended to provide a representative range of values from across the Deben and wider Suffolk estuaries.
	The carbon stock of mudflat and for vegetated salt marsh was calculated from published information (e.g. Thornton et al. 2002; NERC projects; CBESS and the Thematic project Shelf Sea Biogeochemistry, Legge et al., 2020). Literature provided a range of estimates, though this work used the average standing stock values for the top 10 cm depth of mudflats (1647 g C m2, standard error ± 42.9) and salt marshes (3684 g C m2, standard error ± 152).
	Marsh area was identified by shape files (as per Box 3) with the corresponding percentage vegetation cover data and the "standard carbon stock values" for mudflat and salt marsh calculated within the top 10 cm of sediment for each shape file area.
	Healthy salt marsh in East Anglia possess natural internal creeks systems and open areas of sediment, which occupy approximately 12 ± 1.95 % of the marsh area (Green et al. 2009, 2012). Using these measures as a target value for full restoration, the potential increased carbon stock of marsh was calculated based on the assumption that restoration delivers to a state of a healthy vascular plant coverage.
	These calculations are based on a 2 dimensional area basis only, and do not take into account potential sediment accumulation (3 dimensional) that may be needed to raise the sediment bed height to a position within the tidal frame where vascular salt marsh plant species could colonise.
	Using 2016 Environment Agency LIDAR height measurements (Cooper, G., pers. comm.) it was possible to estimate the vertical height of sediment needed in any marsh restoration schemes to result in a restored salt marsh being at the same height as existing marsh at each site. For these calculations, the same carbon values for existing mudflats (10 cm deep sections) were assumed for each of the necessary sections to build the marsh to the prerequisite height.
Applications	This method identifies the provision of carbon sequestration and storage services for East Anglian salt marsh. The method has been applied to identify change in service provision following observable (GoogleEarth 2007- EAortho 2016) and aspirational (restoration based on return to healthy marsh) change.
	Data and software used were freely available and have national coverage. This work was intended to underpin decision making at a local level but could equally inform national or regional accounting or monitoring.
	In terms of informing management decisions, the feasibility of marsh restoration, based on the provision of additional benefit is determined by the timescale to realise the benefits. The rate of salt marsh growth is site specific, though evidence from UK restoration and managed realignment shows vascular plant development is achievable within 5-10 years. Time scales to achieve levels of biodiversity and spatial heterogeneity are much longer in the order of 50-100 years. It should be acknowledged that Slee et al., (2018) did not account for these timescales in their calculations so this work in itself cannot usefully inform decision making without this context.
Future work	
	Finer scale height differences, and a better profile of the organic carbon content of restoring and stabilised marshes could finesse estimates. However, fine scale height modelling would require significant additional data resolution (m^2), and then modelling and computational power to do

this on a spatial basis. For most locations such data do not exist such that higher resolution data would be prohibitively expensive.

Box 5: Service Provision –Provision of Fish (Slee et al., 2018)	
University of Essex	
Requirements	Salt marsh is known to provide nursery habitat for numerous commercially, recreationally and ecologically important species of fish and shellfish. The provision of nursery habitat provides critical habitat for early life stages and therefore can influence catch yields. The Pioneer wanted to understand the relationship between fish abundance and extent of salt marsh. Quantification of fish species per unit area of salt marsh is particularly desirable to influence fishing behaviours and attitudes towards salt marsh.
Available Information	The Environment Agency developed the National Fish Populations Database for waterbodies covered under the Water Framework Directive, which includes coastal and transitional (estuary) waters. Included within this database are; records of fish numbers; species; lengths & weights; as well as some data on ages. These data are publicly available, but subject to access approval. Fish utilisation of coastal habitats has received attention overseas, particular in North America. It has however received relatively little attention in England where structure of marsh differs markedly from America, such that American data is irrelevant. The institute of Fisheries management have started research in England led primarily by S. Colclough. A selection of grey literature is provided below. Colclough, S. R., L. Fonseca, T. Astley, K. Thomas & W. Watts. (2005). Fish utilisation of managed realignments. Fisheries Management and Ecology 12: 351–360.[1] Colclough, S. R. (2017a) Hazlewood Marshes, Alde Estuary, A survey of fish populations associated with the marshes Draft Report February 2017. SC2 Reference: SuffolkWT/001 Colclough & Coates - SC2 Ltd, Chatham, Kent, ME5 9JQ Colclough, S. R. (2017b) Waldringfield Marshes, Deben Estuary, A survey of fish populations associated with a marsh restoration project Draft Report April 2017. SC2 Reference: WMA/001 Colclough & Coates - SC2 Ltd, Chatham, Kent, ME5 9JQ. Fonseca, L., Colclough, S., Hughes, R.G., (2011) "Variations in the feeding of 0-group bass Dicentrarchus labrax (L.) in managed realignment areas and salt marshes in SE England." Hydrobiologia 672.1: 15-
Identified Gaps	Quantifying the contribution of coastal habitat to recreational and commercial fishing activity.
Solutions	Sea Bass (*Dicentrarchus labrax*) are an important species of commercial and recreational interest. The University of Essex estimated daily marsh use of sea bass per 100m2 creek (larval and 1yr+) and calculated potential increased use under restored conditions.
Method Summary	

Green et al. (2009) conducted a comprehensive study of the distribution of fish in five east Anglian marshes (Fig. 3). Using flume net-fish traps placed across creeks, fish numbers were measured on ebbing tides, and standardised as numbers of larval and juvenile fish per tide per 100 m2 extent of salt marsh creeks.

From Green et al. (2009), The University of Essex (Slee, et al., 2018) have taken an average of larval and juvenile (year 1+) sea bass using a set extent of salt marsh per tide, during the relevant seasons on the year. Daily fish use of current marsh extents in the Deben has been estimated.

The potential for daily fish use if restoration occurred has been calculated (using the assumption that healthy salt marsh comprises 88% vegetated surface and 12% are of creeks (form Green et al. 2009).

By using these factors and grouping the individual salt marsh shape files into coherent ecological units, the current and future potential increase in sea bass use were estimated.

It is acknowledged that the estimates are broad: fish use can be vary locally (Green et al. 2012), with seasonal variation (Green et al. 2009, Colclough 2017a), and are dependent on a spawning population of adults to provide a source of larvae and juvenile fish to the estuary.

Additional marsh was calculated to potentially yield an average of 78 fish (1 year +) per tide per hectare of salt marsh (assuming 88% marsh 12% creek).

Below: Google Earth (A) and EA RGBN, images (B,C,D) manipulated through use of ImageJ non-vegetated (red) and vegetated areas (green).
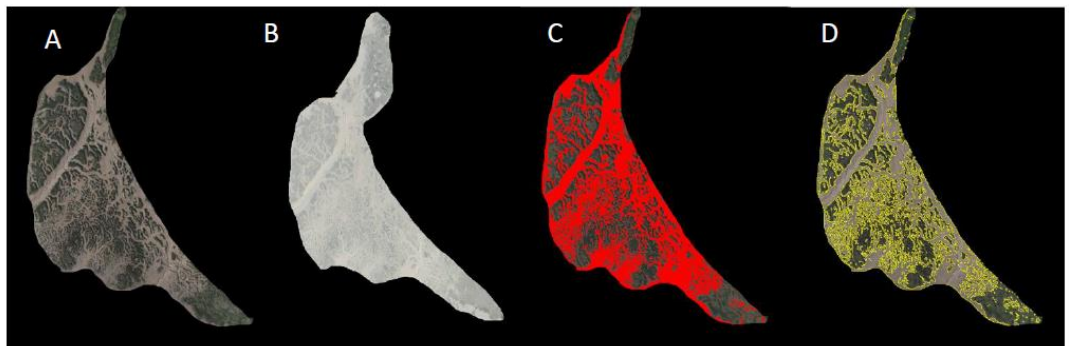
Applications	
	The method provides a crude estimate tool that could be applied where equivalent data exist for other species and geographies. The National Fish Population Dataset is yet to be examined for compatibility with this method but it offers the possibility to understand habitat roles in fishery provisions nationally.
Future work	To overcome the adage that there are plenty more fish in the sea, and therefore define beneficiaries of the service, it is necessary to understand how the survivorship of juveniles in coastal habitats relates to minimum conservation size (42cm circa at 6+ years, Carroll et al., (2014)) and identify the relationship between habitat loss/gain and capture fisheries. Juvenile seabass spend <5 years in coastal habitats and reach maturity at 4-7 years

Conducting similar analysis for other fish species known to inhabit English salt marsh (informed by NFPD) would provide a more comprehensive understanding of the role of salt marsh in supply recreational and commercial markets. |

Box 6: Service Provision – Prevention of Erosion and Sea Defence (Rogers & Möller, 2019)	
UNIVERSITY OF CAMBRIDGE CCRU	
Requirements	To determine the role of estuarine salt marsh in coastal protection.
Available Information	Salt marsh can act as buffers against damaging wave action (Möller et al., 2014). They do this because of two key attributes: (1) they effectively reduce the water depth because the marsh provides a 'platform' relative to the estuarine or sea bed and (2) the vegetation and other features on the marsh make for a rough surface which slows the movement of water. Both attributes have the positive benefit of reducing the threat posed by storm events on any settlement, land or activities on the landward side of the marsh. Physical modelling and empirical testing demonstrated salt marsh extending 40m wide provides a minimum wave height reduction of 15% (Möller et al., 2014) at the coast. Necessary data to define the reductive effect of salt marsh includes: Marsh width; wave fetch; wind speed; marsh height. Marsh width can be determined in GIS systems by analysing Salt marsh polygon data (Box 3) for all coastal and transitional waterbodies in England. Extent is defined from aerial imagery to a resolution of $100mm^2$ and the 2014 data are publicly available via Open Government licence https://environment.data.gov.uk/. The Environment Agency operate the UK National Tide Gauge Network with a 3 month lag on the publication of real-time data online. Lidar Data is available through the Environment agency for 60% of England that can inform coastal (including salt marsh) height relative to chart datum. Wind speed data are available from the Met Office.
Solutions	The University of Cambridge developed a repeatable methodology using the available data sources to quantify the minimum service provision of fringing coastal salt marsh. Analysis can quantify the impact of change (marsh gain/loss) on the coastline.
Method	Factors such as water depth, incoming wave heights, marsh platform width, marsh surface friction all affect the degree to which the presence of salt marsh mitigates wave action. It is difficult to predict likelihood of water depth or wave height conditions for future events. It is also difficult (and expensive) to gather detailed information on the precise characteristics of the marsh surface. It is more easily possible, however, to estimate the *minimum* reduction in waves achieved by any given marsh. This can be achieved using a GIS based approach with relatively simple information (below).

The following diagram illustrates wind speeds and wave dynamics affecting marsh protection:
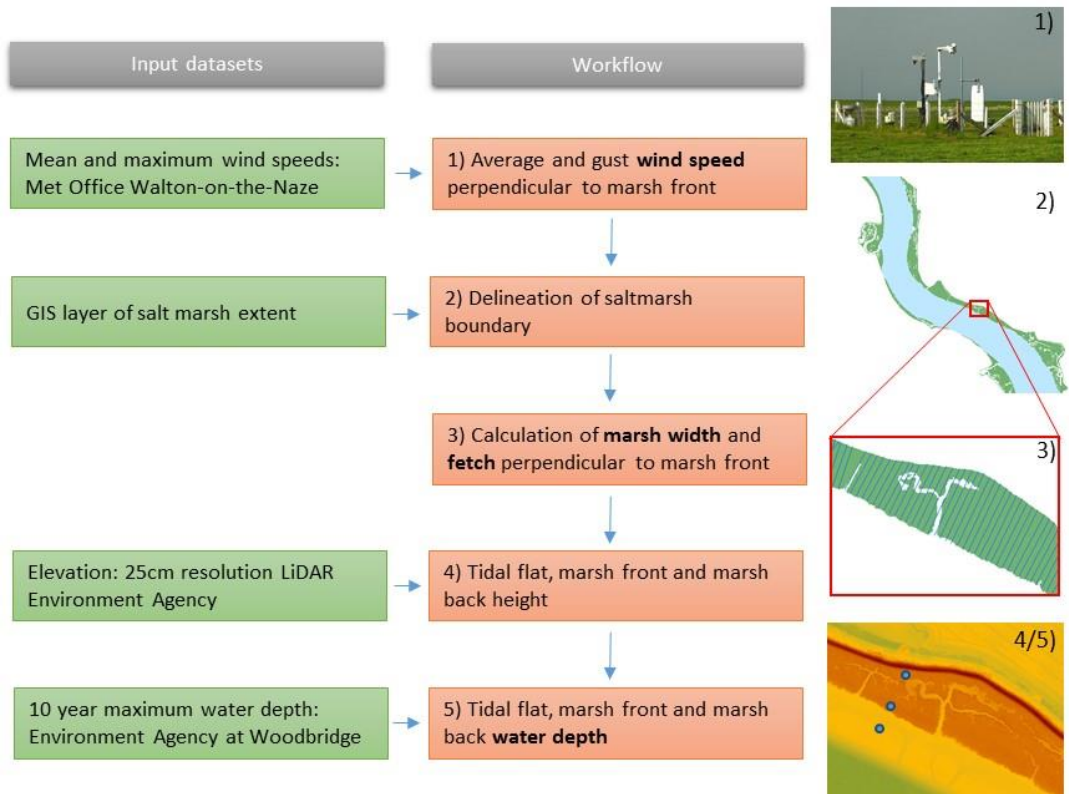
- Highest winds generate largest waves to reach marsh front
- Longest fetch (distance over which wind blows) generates largest waves to reach marsh front
- Deeper water allows for larger waves to reach front of marsh
- Greater water depth difference causes more wave breaking over marsh front
- Wider marsh allows more dissipation of remaining energy due to shallow water & bed roughness

Largest Protection Service:

Exposed sites

and/or

Highest marsh relative to water levels

and/or

Widest marsh

The GIS outputs were provided following the methodology outlined below.

Input datasets	Workflow
Mean and maximum wind speeds: Met Office Walton-on-the-Naze	1) Average and gust **wind speed** perpendicular to marsh front
GIS layer of salt marsh extent	2) Delineation of saltmarsh boundary
	3) Calculation of **marsh width** and **fetch** perpendicular to marsh front
Elevation: 25cm resolution LiDAR Environment Agency	4) Tidal flat, marsh front and marsh back height
10 year maximum water depth: Environment Agency at Woodbridge	5) Tidal flat, marsh front and marsh back **water depth**

Applications.	The approach is applicable to other estuarine sites, provided the key parameters required are available for such estuaries and basic maps of salt marsh and tidal flat elevation and extent are accessible.
	The GIS approach lends itself to the use of Earth Observation data. With the increasing availability of such data, applications can be developed that use our approach alongside similar approaches for the quantification of other ecosystem services and display such information in multiple GIS layers.

	As scientific knowledge on the specific parameters that drive the relative provision of ecosystem services grows, such applications can begin to incorporate an increasing amount of information and can be used as an attractive way to illustrate ecosystem service provision and trade-offs across the regional landscape.

Box 7: Identifying Service provision and valuation – Cultural Services (Grilli et al. Unpublished)

Requirements	Cultural value derived specifically from Suffolk estuarine salt marsh that can be analysed to identify specific locations, features, uses and/or interaction that determine the delivery of cultural ecosystem services.
Available Information	The University of Exeter have developed an Outdoor Recreation Valuation Tool (ORVal) that can predict recreational use of greenspace and estimate a welfare value for that greenspace and impacts of change.
Identified Gaps	ORVal provides valuations based on predefined boundaries, however these were not directly transferable to the Suffolk Pioneer's geography. ORval is unable to isolate the service provision from specific asset types as the land cover data used to inform its estimates use habitat types rather than vegetation classification.
Solutions	Cefas environmental economists derived a value for a positive change in saltmarsh in the Deben estuary. This approach consisted in using a choice experiment that yielded average WTP values for example saltmarsh restoration policies.
Method Summary	The choice of the attributes and levels to be used in this choice experiment was performed in order to replicate and update results from Luisetti et al. (2011).Survey was administered on a sample of East of England residents. Data analysis is ongoing and a scientific paper in preparation.
Applications.	The wider application of value methodologies is dependent on their ability to influence behaviour of decision makers.
Future work.	The analysis of data from the choice experiment is ongoing to elicit economic values for recreation in the Deben estuary saltmarsh. The potential application of elicited values in natural capital and ecosystem services accounting will be explored.

Box 8: Valuation – Provision of Fish and Healthy Climate (Holt, 2018)

Requirements	Monetary valuation of the provision of ecosystem services that is aligned to Office for Natural Statistics natural capital accounting methodologies to ensure outputs can be incorporated at varying scales of accounting.
Identified Gaps	

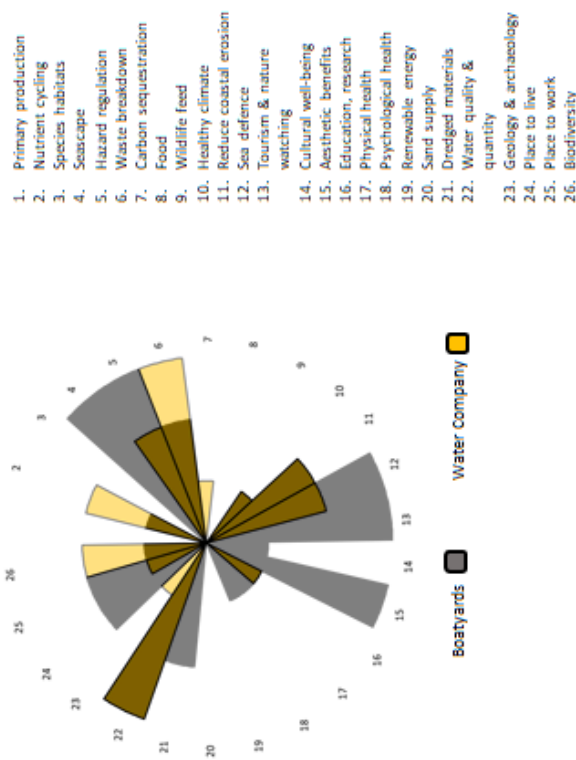|	
	No gap exists in terms of natural capital accounting methodologies (ONS Principles of Natural Capital Accounting, 2017), rather the gap the Pioneer sought to address was the correct application of this methodology to the identified provision of service (Box 4 and 5[26]).
Solutions	The Pioneer commissioned Natural Capital Solutions to apply the ONS accounting methodology to the service provision identified by Slee et al 2018 for: • Carbon Stored per Ha • Projected loss in value of carbon based on conservative erosion rates (1%/year) discounted across management horizons of 5, 10 and 50 years. • Value of carbon sequestration of marsh for Deben marshes as a present value and across 10 and 50 year management horizons. • Value of Seabass production from assessed Deben marsh as a present value and for 10 and 50 year horizons.
Methods	• Production functions of carbon and sea bass production were completed by Slee et al (2018). • Carbon (C) estimates were converted into CO_2 to enable valuation. • The price of CO_2 was derived from the Government's non-traded carbon prices (2019 low: £34, central: £67, high: £101) ([BEIS](#) 2017 prices) to best reflect market price rather than true value. • The tonnes of CO_2 at each site were multiplied by the price per tonne of CO_2. • Carbon will be released from the marsh habitats as they erode or are lost (historically 1% per year). The estimate of carbon lost, and the value of the carbon lost was calculated for 5, 10 and 50-year time horizons at £67. • Carbon sequestration was estimated at a rate of 2.85 t CO_2ha-1yr-1 was used from the Burden et al. (2019) study of restored salt marsh on the Essex coast. • Sequestration rate was multiplied by the area of original and restored salt marsh. • The annual monetary flow of this service was then estimated by multiplying this value by the central non-traded carbon price (£67). • The present value (PV) of the ability of the marsh to sequester carbon into the future was calculated over 10 and 50 year periods, using the discount rates suggested in HM Treasury (2018), and the formula within ONS (2016). Predicted carbon prices for the next 50 years were used to account for the change in value over these time horizons. **Sea bass production** • The production function for sea bass is based on quantitative estimates of the abundance (at low, mean and upper survival rates to 36cm) of juvenile bass up to two years old calculated in Fonseca (2009) for the Blackwater Estuary, Essex rather than from Slee et al (2018) because it was not possible to relate the values in Slee et al., to minimum catch size. • The economic contribution of the bass to the local inshore fishery after five years (the age at which the bass are likely to reach the legal length for harvesting) was then estimated in units of £ per hectare of salt marsh also from Fonseca (2009).

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[26] NCA were commissioned before the coastal protection work of Rogers & Moller (2019) was complete.

	- The average wholesale price from Fonseca (2009) adjusted to 2019 prices, was used to inform value per hectare. These values were multiplied by the area (ha) of the original and restored salt marsh. - The present value (PV) of sea bass production into the future was calculated over 10 and 50 year periods, using the discount rates suggested in HM Treasury (2018), and the formula proposed by the Office for National Statistics. The price per ha was assumed constant in this calculation, due to the absence of data on how it has or may change in the future. - These estimates are based on a number of assumptions that are both ecological and economic.
Applications	The wider application of value methodologies is dependent on their ability to influence behaviour.
Future work	It is widely reported that the typical economic value assigned to common environmental goods is zero on the basis that are free to access. Presenting valuations above zero to decision makers requires a revaluation of benefit analysis. As such, the validity of the numbers generated by the accounting should be tested to gauge their influence.

Its possible to compare different organisations relationships with the environment by overlaying the radar plots. This has been done for boatyards & Anglian Water, below. It can tell you;

- Where organisations have common interests
- Where working together might bring mutual benefits
- What the most important benefits are to the Deben as a whole.

Comparing boatyards & water company reliance on natural benefits

1. Primary production
2. Nutrient cycling
3. Species habitats
4. Seascape
5. Hazard regulation
6. Waste breakdown
7. Carbon sequestration
8. Food
9. Wildlife feed
10. Healthy climate
11. Reduce coastal erosion
12. Sea defence
13. Tourism & nature watching
14. Cultural well-being
15. Aesthetic benefits
16. Education, research
17. Physical health
18. Psychological health
19. Renewable energy
20. Sand supply
21. Dredged materials
22. Water quality & quantity
23. Geology & archaeology
24. Place to live
25. Place to work
26. Biodiversity

Boatyards   Water Company

We think this can become a really useful tool for businesses, both in understanding environmental risk and to identify where partnerships with other organisations could be formed for mutual gain.

It takes a step on from similar work, by understanding how people and place interact. Current tools are more developed, but less specific, like Landscape Enterprise Network and ENCORE

Page 5

Next Steps

a) Visualise the habitats & processes that deliver the benefits shown to be important. This will tell organisations the types of environment important to them, and might wish to protect.

b) Compare the need or organisations with the physical environment in their vicinity (Natural Capital Asset Registers). This will identify risk on a regional scale, and inform what action environmental managers should take for the collective good.
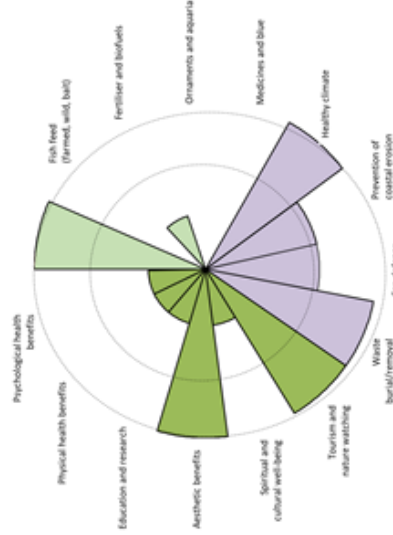
Improvements

We were able to broadly understand how a variety of different organisations relate to and rely upon the benefits from the natural environment. As we know which types of environment provide these benefits, we can infer which environments Suffolk organisations depend upon.

Our test on the Deben estuary is however, not without fault. There is room for improvement in defining what 'benefit' means to the organisations undertaking the assessment and by better defining what activities organisations assesses the benefits against.

For example, some of the list of benefits (derived from the National Ecosystem Assessment) are confusing, and may be duplicated. Likewise, some organisations will consider different timescales when assessing how they benefit – this leads to difficulty in comparing across organisations.

Benefits Provided by Saltmarsh

Psychological health benefits
Physical health benefits
Education and research
Aesthetic benefits
Spiritual and cultural well-being
Tourism and nature watching
Waste burial/removal
Sea defence
Prevention of coastal erosion
Healthy climate
Medicines and blue
Ornaments and aquaria
Fertiliser and biofuels
Fish feed (farmed, wild, bait)

Suffolk Marine Pioneer March 2020

Who should contribute to a healthy environment?

We get lots of benefits from the natural environment, but don't pay directly for them. This often means we take our environment for granted and can harm it inadvertently. Causing this damage risks the functionality of natural systems and the potential loss of the benefits we enjoy. Taking the environment for granted therefore puts businesses and communities at risk.

To alleviate this risk, we need to find ways to pay for environmental enhancement and management. Understanding who should pay towards improving our environment is complicated because you need to know everyone wants and needs, and where they can get it from. On top of this, you get 'freeloaders' who would rather let others pay for them. – Like your friend who will always find an excuse to leave the pub when it's their round!

We wanted to explore which organisations in Suffolk benefit from the natural environment of the Deben Estuary, and how they do so. This should answer the question of who should contribute to improving the environment. After all. You get what you pay for.
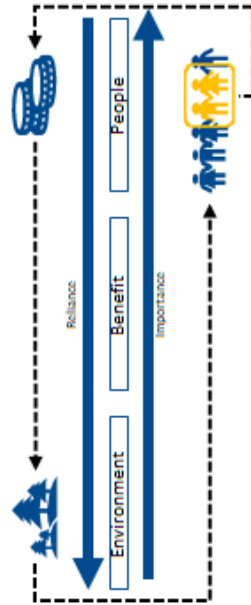
The Pioneer used a scientific approach to logically link people back to the environments they rely on in order to understand who should contribute to the maintenance and improvement of the environment.

To help us understand the links between people and the natural environment the benefits come from, we developed logic chains. This allowed the Pioneer to ground our test in scientific understanding of 'ecosystem services'. This means our approach can be applied by any organisation and for any environment.
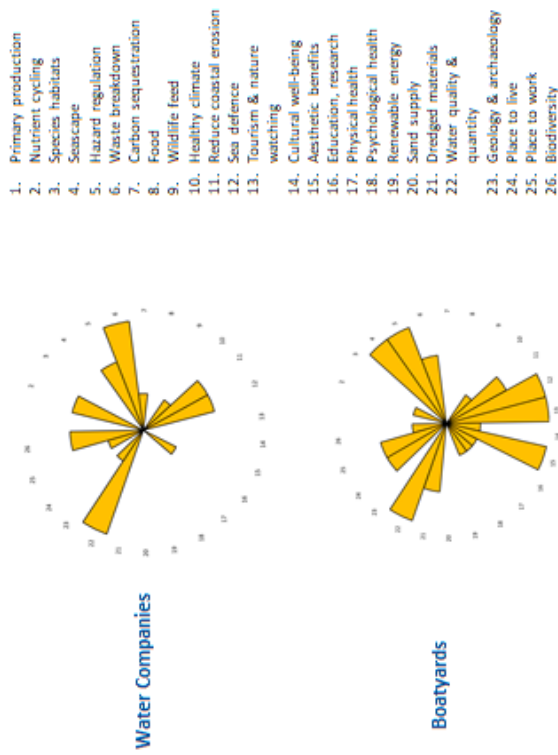
Methods

We worked with businesses and the communities of the Deben estuary to answer the question of how they benefited from the environment.

Participants were asked to think about how they, and others work; what they needed to be successful and what they depended on. We related this to 26 known benefits of the Deben estuary's natural environment in terms of each benefits 'importance' to the organisation. This was completed for

The benefits each organisations relies upon are shown on a radar plot. Larger segments indicate a benefit is relatively more important to that organisation. Examples for the water company and the boatyards of the Deben are shown below.

The relative importance of natural benefits to Suffolk Business

1. Primary production
2. Nutrient cycling
3. Species habitats
4. Seascape
5. Hazard regulation
6. Waste breakdown
7. Carbon sequestration
8. Food
9. Wildlife feed
10. Healthy climate
11. Reduce coastal erosion
12. Sea defence
13. Tourism & nature watching
14. Cultural well-being
15. Aesthetic benefits
16. Education, research
17. Physical health
18. Psychological health
19. Renewable energy
20. Sand supply
21. Dredged materials
22. Water quality & quantity
23. Geology & archaeology
24. Place to live
25. Place to work
26. Biodiversity

Water Companies

Boatyards

Annex 1

Communicating the value of the environment is difficult as it means different things to different folks. The Pioneer wanted to address this problem by inviting the people of East Anglia to capture 'Nature's value' through photography.

This wasn't simply a question of taking pretty pictures of the environment. The images play an important role in helping to start a discussion about the value of nature and can support wider engagement in the natural capital approach. This wider engagement is critical for the success of natural capital.

Scientists classify the different types of benefit the natural world provides into 4 categories of 'ecosystem services'. It is from these ecosystem service that nature's value is gained. Our competition used the categories of ecosystem service to help judge the photos. The briefing given to entrants is presented below. All photographers were asked to include a caption to help explain how their photo matched the category.

Provisioning services are the physical products obtained from ecosystems such as: food, fibre, fuel, genetic resources, biochemicals, natural medicines, pharmaceuticals, water, and building materials.

Regulating services are the benefits we get from ecosystem processes. These don't provide a 'product' like provisioning services but include benefits such as: air quality maintenance, climate regulation, water regulation and purification, erosion control, waste treatment, regulation of human diseases, biological control, pollination, and protection from extreme weather.

Cultural services are the nonphysical benefits people derive from ecosystems. You'll recognise these as things like: spiritual enrichment, reflection, recreation, and aesthetic experiences.

Supporting services are ecosystem services that are necessary for the production of all other ecosystem services. They differ from other services as their impacts on humans are indirect or occur over a long time period to be apparent. Nevertheless, they are perhaps the most important ecosystem services. Examples of supporting services include: production of atmospheric oxygen (through photosynthesis), primary production, soil formation and retention, nutrient cycling, water cycling and provisioning of habitat. It's worth noting that supporting and regulatory services are quite similar. Often, it's just a case of the timespan in which they are delivered that determines which category a particular service falls into.

Category: Supporting Services — **Photographer:** Rob Coleman
This mason bee's home is man-made. Enabling nature to function in our built environment is becoming increasingly important as we reduce natural habitats for personal gain. If man is to continue to thrive, we must recognise our reliance on the natural world and move forward as one. Rob's image depicts a pragmatic mutualism that we can all deliver to the betterment of the environment.

Category: Provisions - Photographer: Natacha Bines

Your eye is first drawn to the pastel hues of the sky, reflected in the water which engages you to recognise air and sea as the natural focus of this image. Natacha challenges this view by acknowledging the mooring posts and wreck as wooden provision.
One tends to see such features as man-made but in fact, the natural service of wood provision is fundamental to the framing of this image. Our initial oversight of this, teamed with the dilapidated hulk offers a great metaphor for how we undervalue the natural world.

Category: Provisions - Photographer: Ben Green

This image takes you on a journey from field to fork. The luscious green of the ripening wheat crop contrasts with the pastel pinks of the sky to draw your attention to the Old Buckenham Windmill. Here we see the process by our food crop can be transformed into something delicious but are reminded that without the wind, we must find other ways of delivering goods to market.